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Geographic Variation in Natural Populations of *Speyeria callippe* (Boisduval) (Lepidoptera: Nymphalidae)

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Abstract.—The geographic variation in 8 wing characters in 35 populations of *Speyeria callippe* (Boisduval) is described and the covariation of the characters summarized. Univariate (SS-STP), discriminant function, and principal components analyses were performed to describe the variation, interpret its origins, and group together geographically adjacent localities that are similar in their characteristics. These techniques are used to test the ability of characters to differentiate subspecies. All three techniques corroborate that these characters, which have previously been used to differentiate 16 subspecies, cannot do so with any statistical significance. Thus, the subspecific taxonomy of *S. callippe* is revised. The presently recognized 16 subspecies are reduced to 3, whose morphological features correlate with their geographic distributions.

The subspecies concept and its utility have been critically evaluted by numerous systematists (Bohme, 1978; Mayr, 1969; Wilson and Brown, 1953), yet many problems remain in defining and naming subspecies. At issue is a growing discontent with an arbitrary taxonomic category, the subspecies, which often fails to accurately describe infraspecific variation. In certain animal groups, such as butterflies, where the ratio of systematists to species is high, minor differences in morphology are accorded relatively high value in determination of taxonomic rank. Mayr (1969) defined the subspecies as "an aggregate of local populations of a species, inhabiting a geographic subdivision of the range of the species, and differing taxonomically from other populations of the species." Clearly the determination of how distinctive geographical segregates of a species must be to warrant formal taxonomic recognition is an arduous task. Most butterfly subspecies are named on the basis of one or a few wing characters, principally slight differences in color, maculation pattern, or size. Generally these differences are intuitively perceived by a worker, rather than supported by statistical analyses of character variation throughout the geographic range of the species.

This study describes the geographic variation in 8 wing characters of *S. callippe*. Characters that have previously been used to differentiate subspecies are analyzed as well as others to discover which are most useful for defining patterns of variation that relate to geographic distribution of the butterflies. Hovanitz (1941, 1943), Howe (1975), Moeck (1957), and Sette (1962) speculated that the variation in several characters, including size, wing color, and silver-spot patterns, of the numerous subspecies of *Speyeria callippe* was clinal. Also they proposed that the pattern of variation in several characters partitioned populations into several geographical segregates or subspecies. Despite the large degree of overlap in the

Figure 1. Geographic distribution of the formerly recognized subspecific taxa of *Speyeria callippe*. Taxa in large capital letters, with a Great Basin distribution, are green-disced populations, whereas those represented by the smaller lower-case letters, with a California-Oregon distribution, are brown-disced populations.

range of variation of numerous wing characters, 16 subspecies are currently recognized (dos Passos, 1964; Miller and Brown, 1981).

Several univariate and multivariate numerical taxonomic techniques were used to analyze the geographic variation in 35 populations scattered throughout the range of *S. callippe*. Based on these analyses and other numerical taxonomic studies (Arnold, 1983, 1985) new conclusions about phenotypic character variation and the infraspecific nomenclature of *Speyeria callippe* are presented. The presently recognized 16 subspecies (Fig. 1) are reduced to three whose morphological features correlate with geography.

DATA COLLECTION AND ANALYSIS

Materials.—Initially, 35 populations or operational taxonomic units (OTU's), were selected for this study (Table 1). Samples of 10 males from each population were chosen by use of a random numbers table. Each sample was composed of individuals collected on the same date at the same locality. The subspecific identity (*sensu* dos Passos, 1964) of each sample was determined. Nineteen additional populations were later used as unknowns to test the effectiveness of the characters under analysis in distinguishing subspecific taxa.

Table 1. List of 35 *Speyeria callippe* populations (OTU's) analyzed using univariate and multivariate statistical techniques. OTU's associated with two subspecific names (e.g., OTU number 2 *comstocki*: *callippe*), indicate that these are intermediate populations.

OTU	OTU no.	Former subspecific identity	Locality data
CALC	1	*comstocki*	San Diego Co., CA
CHEW	2	*comstocki*: *callippe*	Chew's Ridge, Monterey Co., CA
MOCH	3	*callippe*: *comstocki*	Arroyo Mocho, Alameda Co., CA
MILL	4	near *callippe*	Oakland, Alameda Co., CA
LIVE	5	*callippe*: *comstocki*	Los Mochos Cyn., Alameda Co., CA
NCAL	6	*callippe*: *comstocki*	Del Puerto Cyn., Stanislaus Co., CA
CALL	7	*callippe*	San Bruno Mtn., San Mateo Co., CA
NAPA	8	*liliana*	Mt. Veeder, Napa Co., CA
LCAL	9	*liliana*	Boggs Mtn., Lake Co., CA
LRCA	10	*liliana*: *rupestris*	Eel River, Mendocino Co., CA
GLEN	11	*liliana*	Mendocino Pass, Glenn Co., CA
MEND	12	*liliana*	Mendocino Pass, Glenn Co., CA
RCAL	13	*rupestris*	Shasta-Trinity Co. line, CA
TRIN	14	*elaine*: *rupestris*	Mt. Shasta, Siskiyou Co., CA
ECAL	15	*elaine*	Siskiyou Summit, Jackson Co., OR
CALS	16	*sierra*	Red Clover Valley, Plumas Co., CA
PLUM	17	*sierra*: *juba*	Feather River, Plumas Co., CA
BUTT	18	*juba*	Big Battle Creek, Butte Co., CA
FIDD	19	*juba*	10 mi. E. Fiddleton, Amador Co., CA
ICAL	20	*juba*	10 mi. E. Fiddleton, Amador Co., CA
PION	21	*laura*	Washoe Co., NV
ALPI	22	*nevadensis*	Monitor Pass, Alpine Co., CA
MLCA	23	*laurina*	Tulare Co., CA
LAUR	24	*laurina*	Tulare Co., CA
MCAL	25	*macaria*	Glenville, Kern Co., CA
GREE	26	*macaria*: *laurina*	Tehachapi Mtns., Kern Co., CA
TEHA	27	*macaria*	Tehachapi Mtns., Kern Co., CA
SCAL	28	*semivirida*	Harney Co., OR
NEVA	29	*nevadensis*	several counties, NV
HARM	30	*harmonia*	several counties, UT
CALG	31	*calgariana*	Calgary, Alberta, Canada
MEAD	32	*meadii*	several counties, CO
UTAH	33	*harmonia*	several counties, UT
GALL	34	*gallatini*	several counties, WY
GUNN	35	*meadii*	Boulder Co., CO

Table 2. Characters used in univariate, discriminant function and principal component analyses. Character types are continuous (C) and nonordered (NO) multi-state. Non-correlated characters that were used in the numerical taxonomic analyses are denoted by a *.

Character	Name	Type	Veins measured or states
*1) FWLE	forewing length	C	base of R to distal end of M1
2) FWWD	forewing width	C	R4 to 2A at distal margin
*3) FWLW	ratio of forewing length/width	C	ratio of FWLE/FWWD
4) FDCL	forewing discal cell length	C	base of M to its junction with M1
5) FDCW	forewing discal cell width	C	M1 to M3 at distal end of cell
*6) FDLW	ratio of forewing discal cell length/width	C	ratio of FDCL/FDCW
7) HWLE	hindwing length	C	base of M to distal end of M1
8) HWWD	hindwing width	C	Rs to 2A at distal margin
*9) HWLW	ratio of hindwing length/width	C	ratio of HWLE/HWWD
*10) HDCL	hindwing discal cell length	C	base of M to its junction with M1
11) HDCW	hindwing discal cell width	C	M1 to M3 at distal margin
12) HDLW	ratio of hindwing discal cell length/width	C	ratio of HDCL/HCDW
*13) DISC	disc color of hindwing venter	NO	green, brown, or green and brown
*14) SUHW	silver spot pattern on hindwing	NO	none, only near body, only distal, or entire wing
*15) USGC	ground color of dorsal facies	NO	pale yellow, yellow, orange, or reddish-orange

Characters.—Twelve quantitative (continuous) and 3 qualitative (non-ordered) wing characters (Table 2) were measured for each of the 350 individuals. Scores for the 10 males in each population were averaged to derive a population score for each character. Continuous characters were measured along specified veins with dial calipers to the nearest 0.1 mm. These characters were selected based on their ease of measurement. Overall size has been previously used to delimit some of the subspecies (Howe, 1975; dos Passos and Grey, 1947), thus the continuous characters were analyzed in an attempt to define the range of size variation in each subspecies. Length and width raw data were transformed logarithmically to standardize the data prior to analysis. Thus each character contributes toward the overall resemblance inversely in proportion to its variability among the entire set of OTU's. Characters with a small range of variation contribute equally as characters with a large range of variation. The characters described by ratios were, by definition (Clifford and Stephenson, 1975), transformed. A histogram for each continuous character was plotted to verify that its distribution was normal. For the three non-ordered characters, each specimen was compared to a series of standards representing each character state. Pearson product-moment correlation coefficients were calculated for each pair of characters to determine the extent each character imparts unique information as opposed to information in common with the other characters being analyzed.

Data analysis.—The approach used to analyze geographic variation in the morphological characters was as follows:

1) partitioning of the variation of each character by analysis of variance (univariate or SS-STP analysis);

2) correlation of characters in order to represent the variation in them by a smaller number of factors (principal components analysis);

3) simultaneous comparison of the variation in all characters to portray the similarities between populations and assess the degree of geographic segregation of similar populations (discriminant function analysis);

4) test the ability of the characters used to differentiate the 16 subspecies and determine the best subspecific classification.

RESULTS

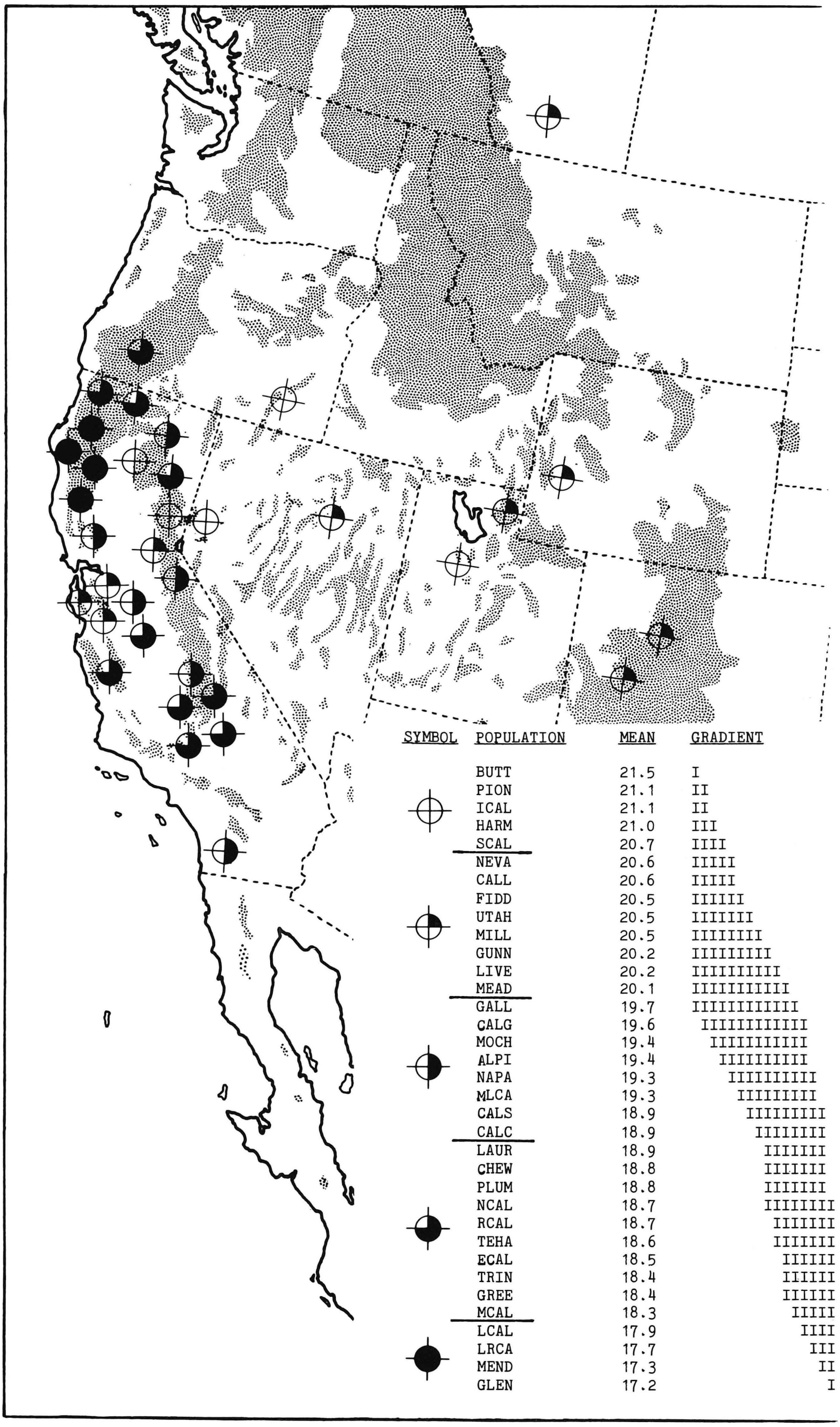
Character correlations.—Mean character states for each population were used to compute the correlation coefficient between every pair of the 15 characters originally measured. The correlation between characters measures the similarity (concordance) of their patterns of geographic variation. Seven of the characters were highly correlated with one or more other characters (>0.70). These were eliminated from further numerical taxonomic analyses. Thus the geographic variation in 8 uncorrelated or weakly correlated characters, FWLE, FWLW, FDLW, HWLW, HDCL, DISC, USGC, and SUHW, was analyzed (Table 2).

Univariate analysis.—The recognition of 16 subspecies (dos Passos, 1964) and previous analyses of infraspecific variation (Hovanitz, 1941, 1943) suggest that the character variation is discontinuous and that the range of *callippe* can be divided into different homogeneous regions. This categorization can be tested by using multiple comparison techniques (Sokal and Rohlf, 1969).

In order to ascertain which characters could partition the 35 populations into statistically significant subsets, analysis of variance over all localities was performed for each of the 8 morphometric characters using Power's (1970) version of Gabriel's (1964) simultaneous test procedure (SS-STP), a multiple comparison test between means (Gabriel and Sokal, 1969). This procedure calculates character means of populations, ranks the means for each character, and computes homogeneous subsets of means based on the variances. Computations were made using the computer program UNIVAR (Moss, 1969).

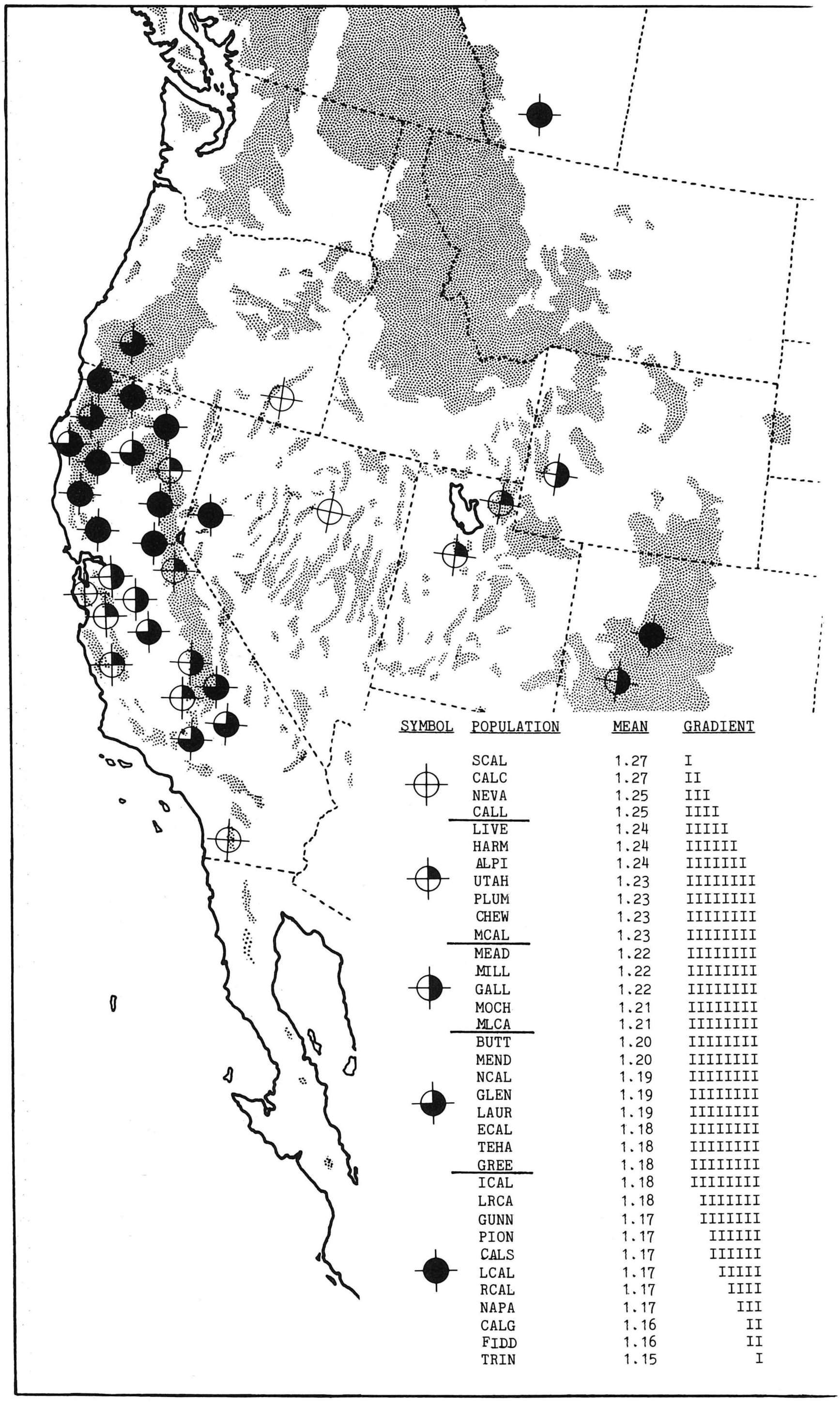
Population means were plotted for each character to examine patterns of variation. Following the technique of Doyen (1973), shaded circles appear to the left of the ranked means on the accompanying distribution maps (Figs. 2–9). These circles do not correlate with the overlapping subsets of the STP technique, but to a second grouping of the means based on dividing the total range of ranked means for each character into 5 equal intervals. Largest values are represented by open circles, and smallest values by closed circles.

Only one character, ventral disc color (DISC) exhibited variation concordant with geography. All brown OTU's (depicted by open circles in Fig. 9) occur from the Sierra Nevada Mountain range to the west coast, while all green populations (black circles) are located in the Great Basin and Rocky Mtns. (Fig. 9). The green-brown intermediates (half open-half black circles) are from southern Oregon, an



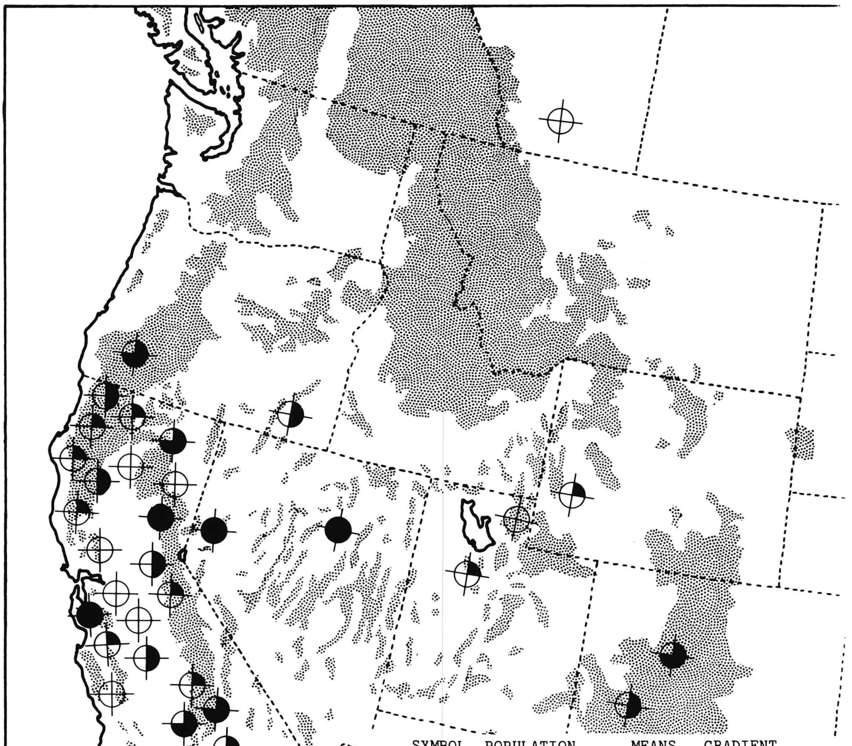
SYMBOL	POPULATION	MEAN	GRADIENT
	BUTT	21.5	I
	PION	21.1	II
○	ICAL	21.1	II
	HARM	21.0	III
	SCAL	20.7	IIII
	NEVA	20.6	IIIII
	CALL	20.6	IIIII
	FIDD	20.5	IIIIII
◔	UTAH	20.5	IIIIIII
	MILL	20.5	IIIIIIII
	GUNN	20.2	IIIIIIIII
	LIVE	20.2	IIIIIIIIII
	MEAD	20.1	IIIIIIIIIII
	GALL	19.7	IIIIIIIIIIII
	CALG	19.6	IIIIIIIIIIII
	MOCH	19.4	IIIIIIIIIII
◑	ALPI	19.4	IIIIIIIIII
	NAPA	19.3	IIIIIIIIII
	MLCA	19.3	IIIIIIIII
	CALS	18.9	IIIIIIIII
	CALC	18.9	IIIIIIII
	LAUR	18.9	IIIIIII
	CHEW	18.8	IIIIIII
	PLUM	18.8	IIIIIII
	NCAL	18.7	IIIIIIII
◕	RCAL	18.7	IIIIIII
	TEHA	18.6	IIIIIII
	ECAL	18.5	IIIIII
	TRIN	18.4	IIIIII
	GREE	18.4	IIIIII
	MCAL	18.3	IIIII
	LCAL	17.9	IIII
●	LRCA	17.7	III
	MEND	17.3	II
	GLEN	17.2	I

Figure 2. Results of univariate (SS-STP) analysis for character FWLE. The circles are used to check for clinal variation in FWLE, after the technique of Doyen (1973).



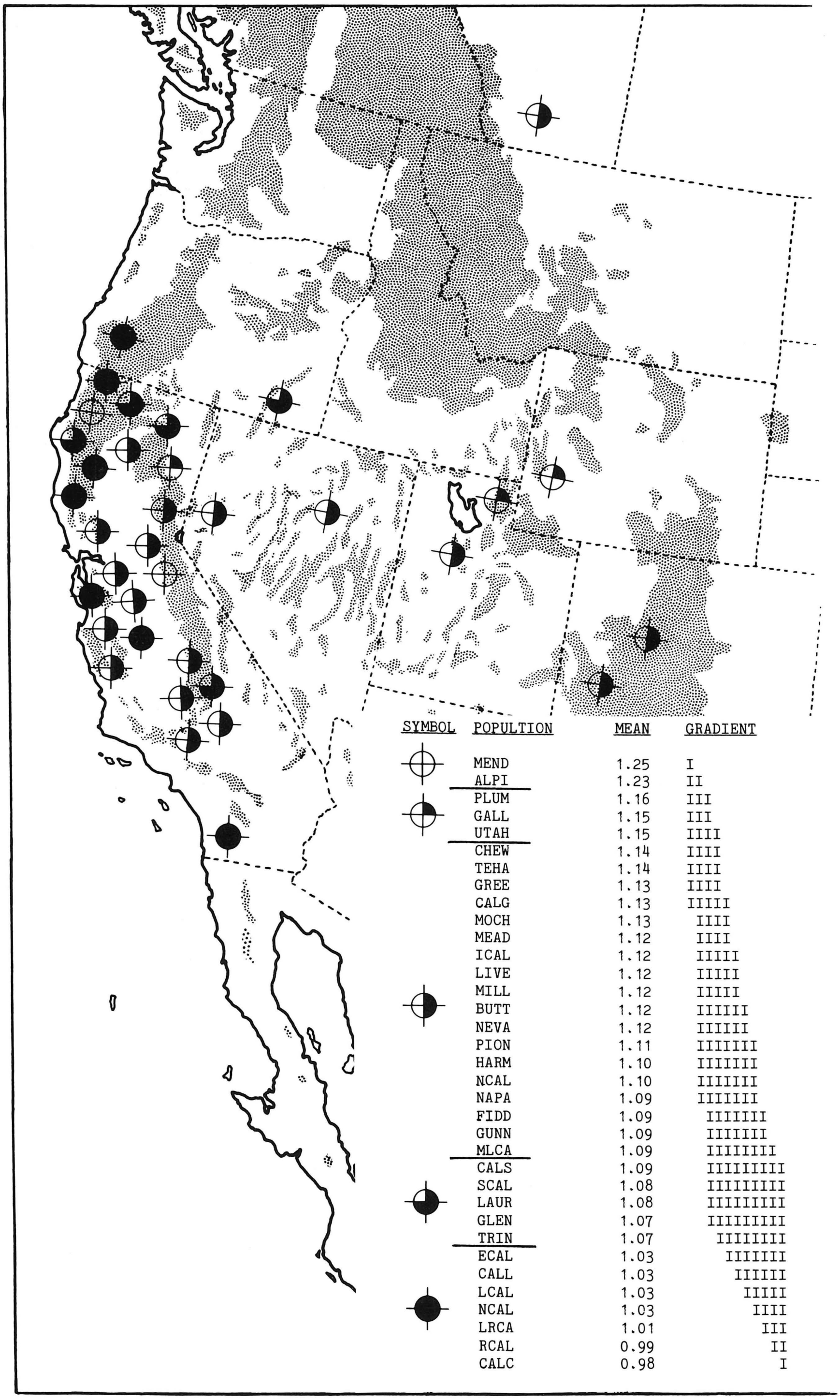
SYMBOL	POPULATION	MEAN	GRADIENT
○	SCAL	1.27	I
	CALC	1.27	II
	NEVA	1.25	III
	CALL	1.25	IIII
◔	LIVE	1.24	IIIII
	HARM	1.24	IIIIII
	ALPI	1.24	IIIIIII
	UTAH	1.23	IIIIIIII
	PLUM	1.23	IIIIIIII
	CHEW	1.23	IIIIIIII
	MCAL	1.23	IIIIIIII
◑	MEAD	1.22	IIIIIIII
	MILL	1.22	IIIIIIII
	GALL	1.22	IIIIIIII
	MOCH	1.21	IIIIIIII
	MLCA	1.21	IIIIIIII
◕	BUTT	1.20	IIIIIIII
	MEND	1.20	IIIIIIII
	NCAL	1.19	IIIIIIII
	GLEN	1.19	IIIIIIII
	LAUR	1.19	IIIIIIII
	ECAL	1.18	IIIIIIII
	TEHA	1.18	IIIIIIII
	GREE	1.18	IIIIIIII
●	ICAL	1.18	IIIIIIII
	LRCA	1.18	IIIIIII
	GUNN	1.17	IIIIIII
	PION	1.17	IIIIII
	CALS	1.17	IIIIII
	LCAL	1.17	IIIII
	RCAL	1.17	IIII
	NAPA	1.17	III
	CALG	1.16	II
	FIDD	1.16	II
	TRIN	1.15	I

Figure 3. Results of univariate (SS-STP) analysis for character FWLW. The circles are used to check for clinal variation in FWLW, after the technique of Doyen (1973).



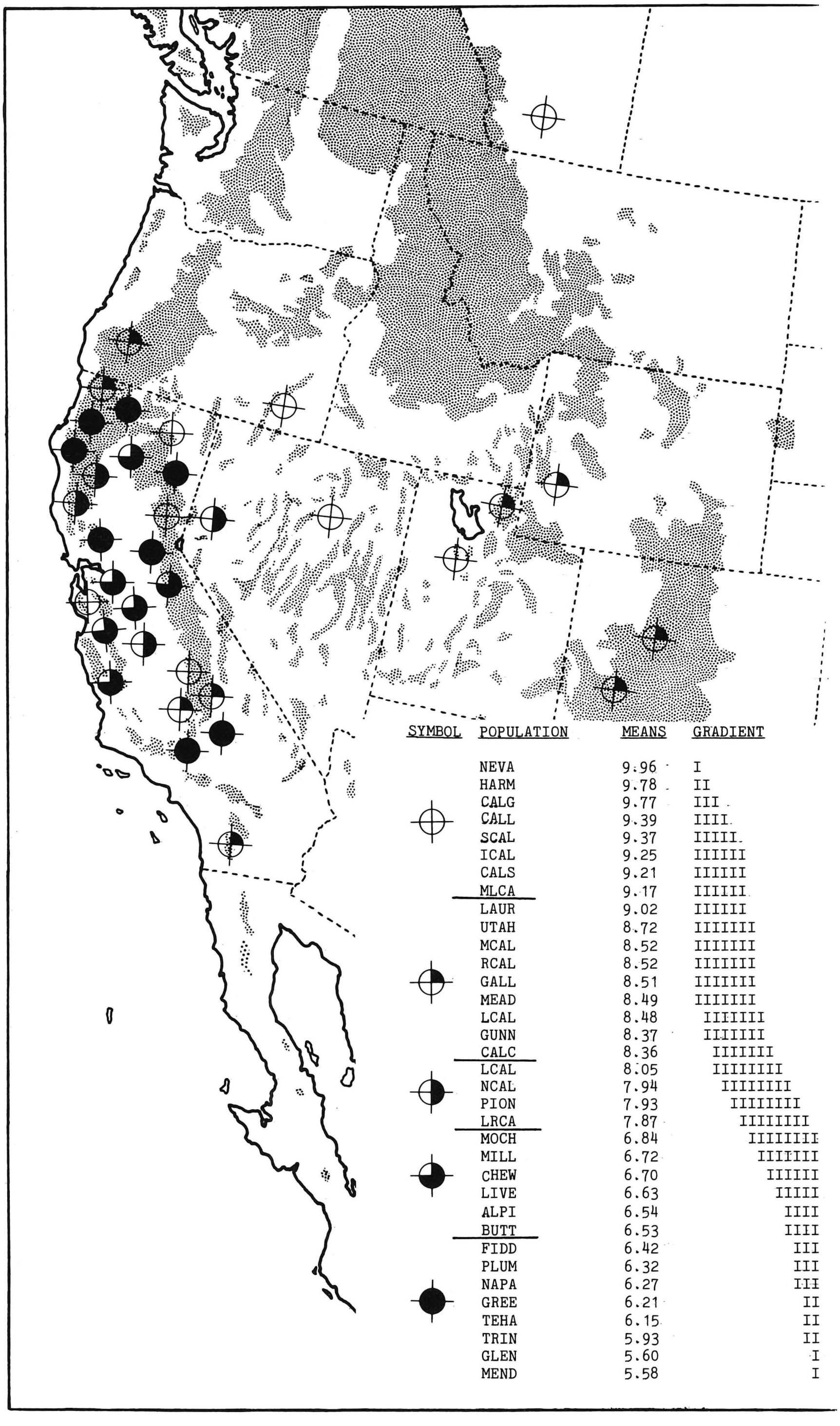
SYMBOL	POPULATION	MEANS	GRADIENT
⊕	PLUM	3.55	I
	CHEW	3.50	II
	MILL	3.49	III
	NAPA	3.47	IIII
	CALG	3.43	IIIII
	BUTT	3.43	IIIII
	MOCH	3.43	IIIIII
	UTAH	3.42	IIIIII
	TEHA	3.42	IIIIIII
◔	GALL	3.39	IIIIIIII
	TRIN	3.38	IIIIIIIII
	ALPI	3.38	IIIIIIIIII
	GLEN	3.37	IIIIIIIIIII
	LIVE	3.32	IIIIIIIIIIII
	HARM	3.30	IIIIIIIIIIIII
	LCAL	3.28	IIIIIIIIIIIII
	MEND	3.28	IIIIIIIIIIIII
	MLCA	3.26	IIIIIIIIIIIII
◑	SCAL	3.24	IIIIIIIIIIIII
	GREE	3.23	IIIIIIIIIIIIII
	NCAL	3.22	IIIIIIIIIIIIII
	RCAL	3.22	IIIIIIIIIIIII
	LRCA	3.21	IIIIIIIIIIIII
	FIDD	3.15	IIIIIIIIIIII
	CALC	3.12	IIIIIIIIIII
	MEAD	3.11	IIIIIIIIII
◕	GUNN	3.08	IIIIIIIII
	PION	3.08	IIIIIIII
	LAUR	3.06	IIIIIII
	MCAL	3.06	IIIIII
	CALS	3.06	IIIII
	ECAL	3.03	IIII
	ICAL	2.99	III
●	NEVA	2.96	II
	CALL	2.78	I

Figure 4. Results of univariate (SS-STP) analysis for character FDLW. The circles are used to check for clinal variation in FDLW, after the technique of Doyen (1973).



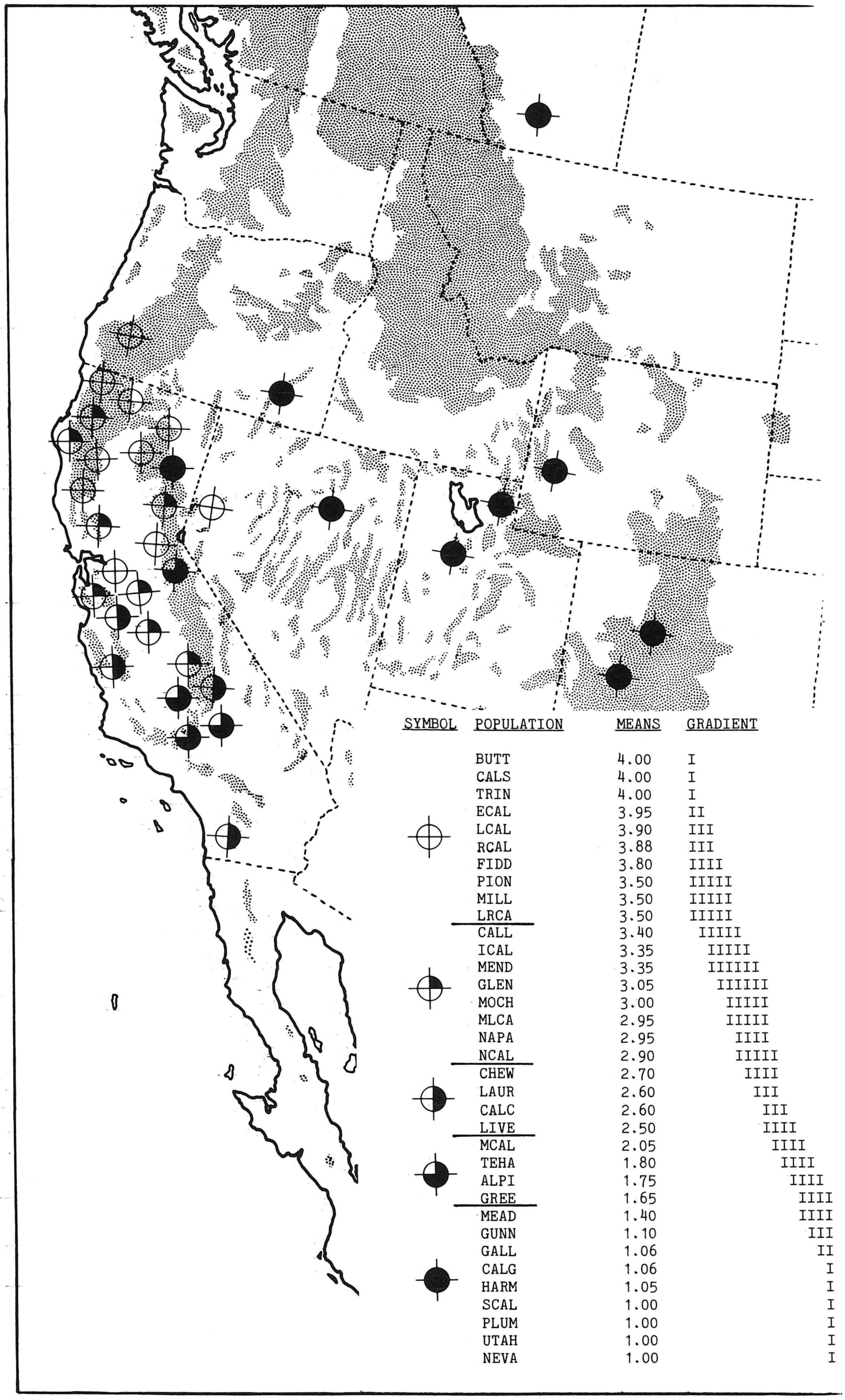
SYMBOL	POPULTION	MEAN	GRADIENT
⊕	MEND	1.25	I
	ALPI	1.23	II
◔	PLUM	1.16	III
	GALL	1.15	III
	UTAH	1.15	IIII
◑	CHEW	1.14	IIII
	TEHA	1.14	IIII
	GREE	1.13	IIII
	CALG	1.13	IIIII
	MOCH	1.13	IIII
	MEAD	1.12	IIII
	ICAL	1.12	IIIII
	LIVE	1.12	IIIII
	MILL	1.12	IIIII
	BUTT	1.12	IIIIII
	NEVA	1.12	IIIIII
	PION	1.11	IIIIIII
	HARM	1.10	IIIIIII
	NCAL	1.10	IIIIIII
	NAPA	1.09	IIIIIII
	FIDD	1.09	IIIIIII
	GUNN	1.09	IIIIIII
	MLCA	1.09	IIIIIIII
◕	CALS	1.09	IIIIIIIII
	SCAL	1.08	IIIIIIIII
	LAUR	1.08	IIIIIIIII
	GLEN	1.07	IIIIIIIII
	TRIN	1.07	IIIIIIII
●	ECAL	1.03	IIIIIII
	CALL	1.03	IIIIII
	LCAL	1.03	IIIII
	NCAL	1.03	IIII
	LRCA	1.01	III
	RCAL	0.99	II
	CALC	0.98	I

Figure 5. Results of the univariate (SS-STP) analysis for character HWLW. The circles are used to check for clinal variation in HWLW, after the technique of Doyen (1973).



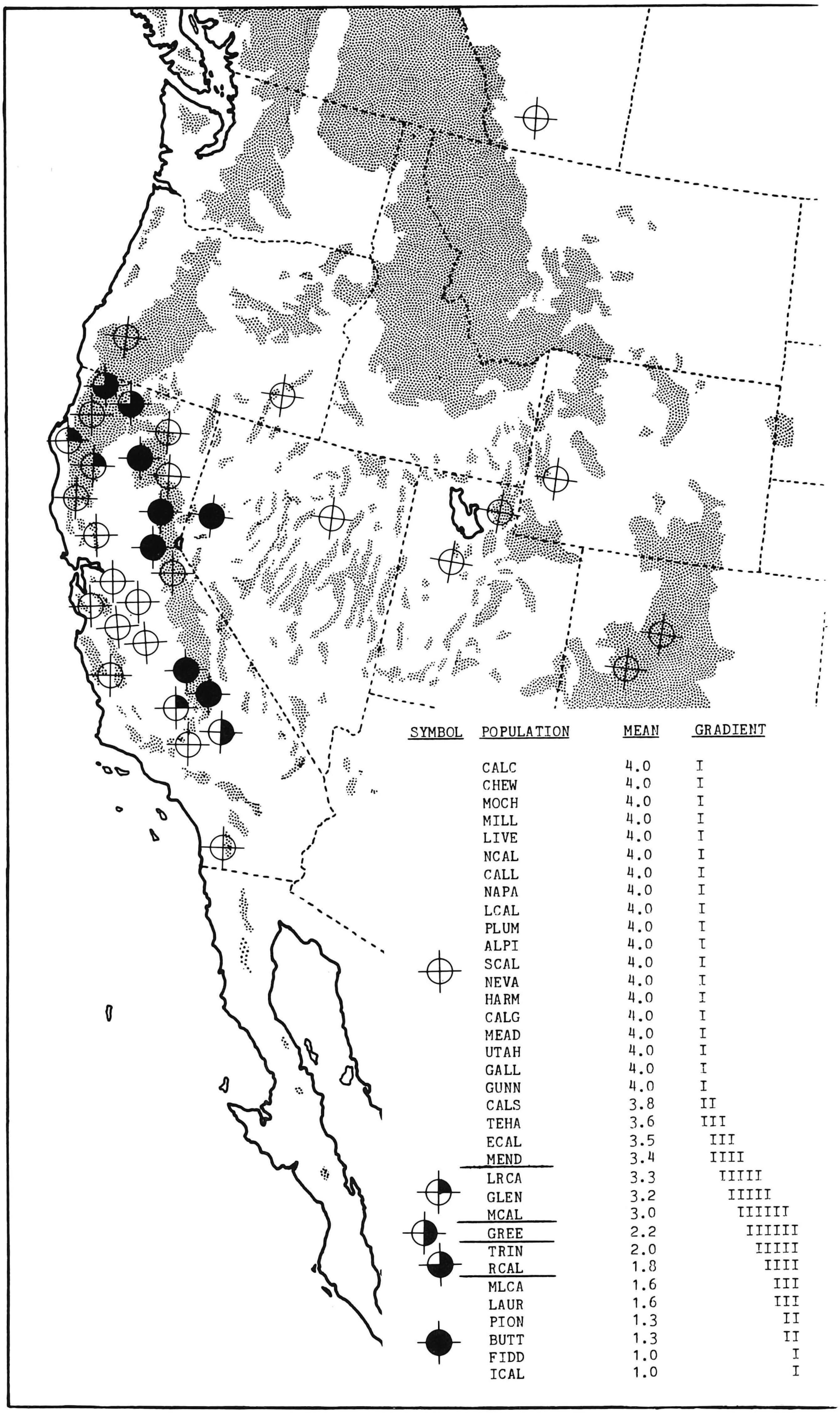
SYMBOL	POPULATION	MEANS	GRADIENT
⊕	NEVA	9.96	I
	HARM	9.78	II
	CALG	9.77	III
	CALL	9.39	IIII
	SCAL	9.37	IIIII
	ICAL	9.25	IIIIII
	CALS	9.21	IIIIII
	MLCA	9.17	IIIIII
◔	LAUR	9.02	IIIIII
	UTAH	8.72	IIIIIII
	MCAL	8.52	IIIIIII
	RCAL	8.52	IIIIIII
	GALL	8.51	IIIIIII
	MEAD	8.49	IIIIIII
	LCAL	8.48	IIIIIII
	GUNN	8.37	IIIIIII
	CALC	8.36	IIIIIII
◑	LCAL	8.05	IIIIIIII
	NCAL	7.94	IIIIIIII
	PION	7.93	IIIIIIII
	LRCA	7.87	IIIIIIII
◕	MOCH	6.84	IIIIIIII
	MILL	6.72	IIIIIII
	CHEW	6.70	IIIIII
	LIVE	6.63	IIIII
	ALPI	6.54	IIII
	BUTT	6.53	IIII
●	FIDD	6.42	III
	PLUM	6.32	III
	NAPA	6.27	III
	GREE	6.21	II
	TEHA	6.15	II
	TRIN	5.93	II
	GLEN	5.60	I
	MEND	5.58	I

Figure 6. Results of the univariate (SS-STP) analysis for character HDCL. The circles are used to check for clinal variation in HDCL, after the technique of Doyen (1973).



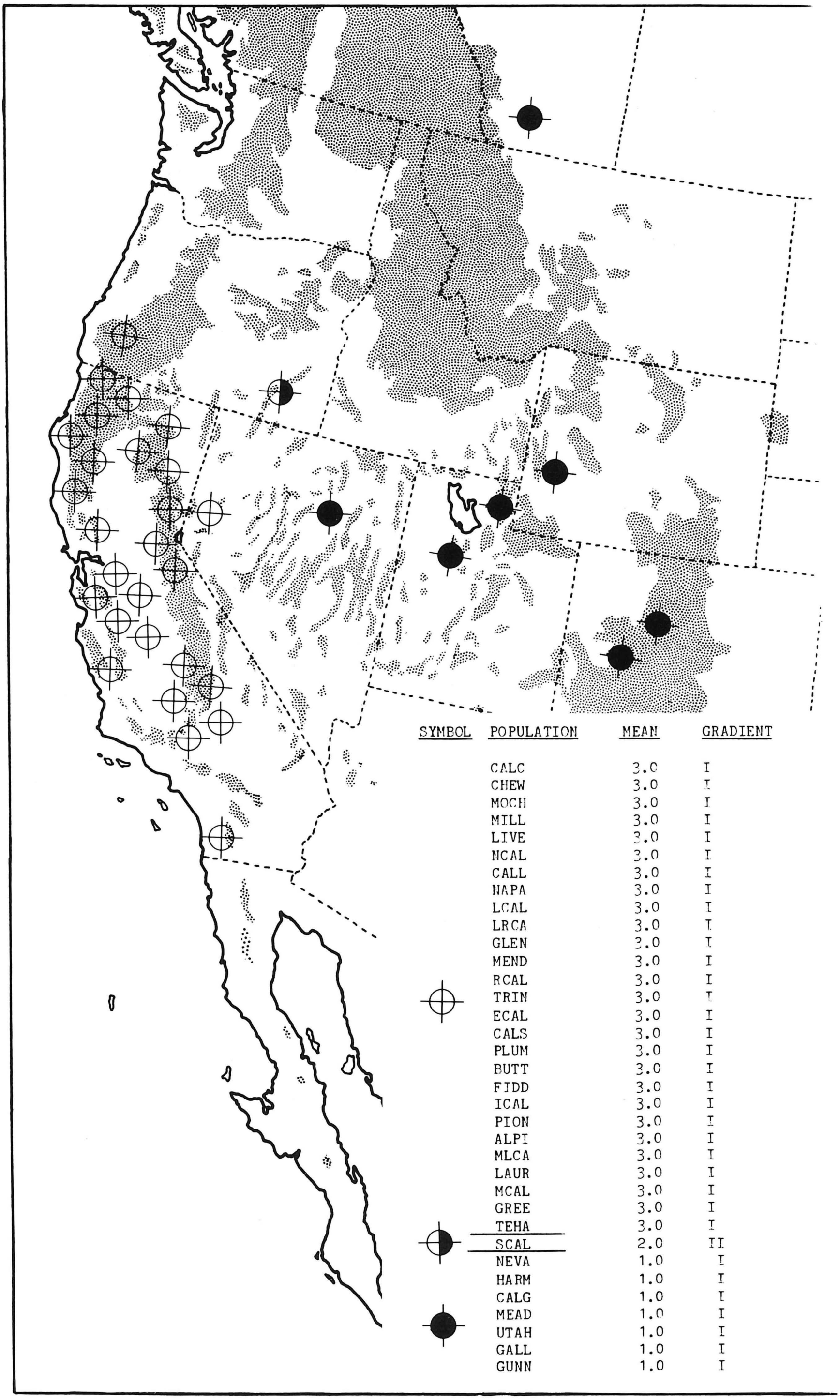
SYMBOL	POPULATION	MEANS	GRADIENT
⊕	BUTT	4.00	I
	CALS	4.00	I
	TRIN	4.00	I
	ECAL	3.95	II
	LCAL	3.90	III
	RCAL	3.88	III
	FIDD	3.80	IIII
	PION	3.50	IIIII
	MILL	3.50	IIIII
	LRCA	3.50	IIIII
◔	CALL	3.40	IIIII
	ICAL	3.35	IIIII
	MEND	3.35	IIIIII
	GLEN	3.05	IIIIII
	MOCH	3.00	IIIII
	MLCA	2.95	IIIII
	NAPA	2.95	IIII
	NCAL	2.90	IIIII
◑	CHEW	2.70	IIII
	LAUR	2.60	III
	CALC	2.60	III
	LIVE	2.50	IIII
◕	MCAL	2.05	IIII
	TEHA	1.80	IIII
	ALPI	1.75	IIII
	GREE	1.65	IIII
●	MEAD	1.40	IIII
	GUNN	1.10	III
	GALL	1.06	II
	CALG	1.06	I
	HARM	1.05	I
	SCAL	1.00	I
	PLUM	1.00	I
	UTAH	1.00	I
	NEVA	1.00	I

Figure 7. Results of the univariate (SS-STP) analysis for character USGC. The circles are used to check for clinal variation in USGC, after the technique of Doyen (1973).



SYMBOL	POPULATION	MEAN	GRADIENT
⊕	CALC	4.0	I
	CHEW	4.0	I
	MOCH	4.0	I
	MILL	4.0	I
	LIVE	4.0	I
	NCAL	4.0	I
	CALL	4.0	I
	NAPA	4.0	I
	LCAL	4.0	I
	PLUM	4.0	I
	ALPI	4.0	I
	SCAL	4.0	I
	NEVA	4.0	I
	HARM	4.0	I
	CALG	4.0	I
	MEAD	4.0	I
	UTAH	4.0	I
	GALL	4.0	I
	GUNN	4.0	I
	CALS	3.8	II
	TEHA	3.6	III
	ECAL	3.5	III
	MEND	3.4	IIII
◔	LRCA	3.3	IIIII
	GLEN	3.2	IIIII
	MCAL	3.0	IIIIII
◑	GREE	2.2	IIIIII
◕	TRIN	2.0	IIIII
	RCAL	1.8	IIII
●	MLCA	1.6	III
	LAUR	1.6	III
	PION	1.3	II
	BUTT	1.3	II
	FIDD	1.0	I
	ICAL	1.0	I

Figure 8. Results of the univariate (SS-STP) analysis for character SUHW. The circles are used to check for clinal variation in SUHW, after the technique of Doyen (1973).



SYMBOL	POPULATION	MEAN	GRADIENT
⊕	CALC	3.0	I
	CHEW	3.0	I
	MOCH	3.0	I
	MILL	3.0	I
	LIVE	3.0	I
	NCAL	3.0	I
	CALL	3.0	I
	NAPA	3.0	I
	LCAL	3.0	I
	LRCA	3.0	I
	GLEN	3.0	I
	MEND	3.0	I
	RCAL	3.0	I
	TRIN	3.0	I
	ECAL	3.0	I
	CALS	3.0	I
	PLUM	3.0	I
	BUTT	3.0	I
	FIDD	3.0	I
	ICAL	3.0	I
	PION	3.0	I
	ALPI	3.0	I
	MLCA	3.0	I
	LAUR	3.0	I
	MCAL	3.0	I
	GREE	3.0	I
	TEHA	3.0	I
◐	SCAL	2.0	II
●	NEVA	1.0	I
	HARM	1.0	I
	CALG	1.0	I
	MEAD	1.0	I
	UTAH	1.0	I
	GALL	1.0	I
	GUNN	1.0	I

Figure 9. Results of the univariate (SS-STP) analysis for character DISC. The circles are used to check for clinal variation in DISC, after the technique of Doyen (1973).

area where Great Basin and Cascade populations may naturally come into contact. Discordant variation was noted for the remaining 7 characters (Figs. 2–8), each of which was characterized by abrupt discontinuities. Only one character, FWLE (Fig. 2), offered a hint of localized clinal variation. The SS-STP subsets of the other 7 characters included considerable overlap of green and brown populations.

Discriminant function analyses.—With this technique, measurements of two or more characters are weighed and combined linearly to provide maximal separation for two or more groups. Each analysis begins with groups of known identity, in this case the 16 subspecies *sensu* dos Passos (1964) and Miller and Brown (1981). This multivariate method uses the non-overlapping information contributed by each character to produce a linear function that will classify the known specimens with a minimum probability of misidentification. Different combinations of characters may be used to achieve statistical distinction between groups. These procedures assist in determining which characters most effectively partition the OTU's into groups.

Direct and step-wise discriminant function analyses were performed on the same data matrix using the Mahalanobis generalized distance, D^2 (Klecka, 1975), to measure phenetic similarity of groups. The 8 characters were first analyzed using the direct method, where all variables are simultaneously entered into the analysis. Discriminant analysis defines axes through the multi-dimensional clusters of individuals resulting in the maximum separation of the clusters.

Later, a step-wise analysis was performed, in which characters were added or removed from the discriminant function analysis based on their contribution to the total distance among multivariate means. This criterion is measured by their F-values, a statistical indication of the relative importance of each character. Characters having the largest F-values are repeatedly selected for partitioning groups of individuals (i.e., clusters) as they contribute more to the classification process. Each step adds the character with the next highest F-value to yield the greatest separation of clusters. Thus the step-wise procedure indicates a character's importance in separating groups, and the least number of characters necessary to separate the clusters.

Both analyses revealed that ventral disc color (DISC), a non-parametric character, had the greatest power of separation based on the F-values for each of the 8 characters (Table 3). DISC could separate all green populations from all brown populations, but could not significantly separate any subsets within the green or brown populations. According to the F-values (Table 3), the next most powerful separation was based upon a parametric character, HDCL, but it could not separate the populations into meaningful clusters. DISC was the only character which could significantly separate local populations.

Linear discriminant function analysis also provides an objective means by which unknown populations can be classified based on the analyses of the reference groups. The scores for individuals from each group form distributions, each with a mean score. The midpoint between mean scores is used to determine group membership, because this point gives the minimum misclassification. Unless the separation of known groups is complete, scores for some specimens will fall within the range of scores delimiting another population, and these individuals would be misclassified. The rate of misclassification of known specimens provides a measure to the effectiveness of a set of characters in identifying new specimens.

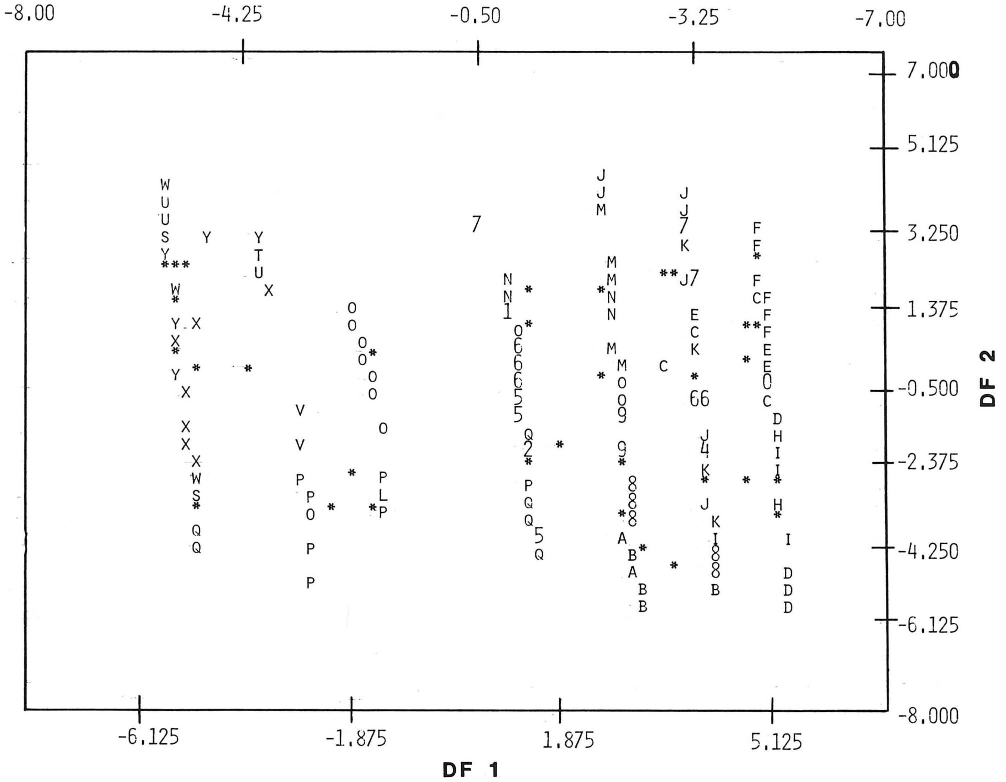


Figure 10. Territorial map of individuals in the 35 *Speyeria callippe* populations (represented by letters A–Z and numbers 0–9) based upon discriminant function scores 1 and 2 (axes are labelled DF 1 and DF 2). Centroids of the 35 populations are indicated by stars. Note the extensive amount of overlap by individuals of different populations.

The classification routine correctly identified only 82 of 190 unknowns (43.2%) as members of the local populations to which they actually belong. As a double check, the 350 individuals which composed the reference populations were then run as unknowns. Only 161/350 (46.0%) of the individuals were correctly classified. Thus most individuals were classified as having their highest group probability as members of populations other than that to which they actually belong. The territorial map of discriminant score 1 vs. score 2 illustrates this degree of overlap among populations (Fig. 10).

In order to remove any bias introduced into the discriminant functions due to the three non-parametric (qualitative) characters, a third analysis using only the 5 continuous characters to partition OTU's was performed. During the classification routine only 60/190 unknowns (31.6%) and 119/350 (34.0%) reference individuals were correctly classified. This strongly suggests that overall size is a poor character for distinguishing subspecies of *S. callippe.*

Principal components analysis (PCA).—The prior assignment of populations into arbitrary reference groups is not necessary with this technique. Combinations of character axes (eigenvectors) representing OTU's are transformed to uncorre-

Table 3. Ranking of characters based on their ability to partition populations (OTU's) as determined by step-wise discriminant function analysis. Higher F-values indicate characters which best discriminate between groups.

Character	F to enter or remove
13) DISC	129.9
10) HDCL	35.9
15) USGC	24.6
1) FWLE	7.9
9) HWLW	1.2
3) FWLW	1.1
14) SUHW	1.0
6) FDLW	0.9

lated axes represented in an n-dimensional character hyperspace. The first component accounts for the greatest percentage of variation, the second accounts for the next greatest percentage of variation, etc., until all variation among all OTU's is expressed. Thus, the spatial relationships between OTU's in the n-dimensional character space are preserved while the axes are rotated. If a major proportion of the variability between characters is explained by the first 3 eigenvectors, the OTU's can be represented in 3-dimensions without much distortion to their real relationships. Factor loadings for all characters on each component provide a basis for inferring which characters are discriminatory and which are uncorrelated.

The first three principal components accounted for 83.2% of the variance observed (Table 4). Factor loadings for the three non-ordered state characters are all near zero along the first and second principal components. This indicates that the qualitative characters contribute little to the character variation along these components. In contrast, the five continuous characters exhibit higher loadings along the first and second components. The relative homogeneity of eigenvalues suggest that the continuous characters along these principal components reflect general size factors for the OTU's.

Continuous characters along the third component have low loadings, while the non-ordered state characters exhibit higher loadings. This indicates that the non-ordered characters are instrumental in explaining the variation along this component. Continuous characters express differences due to size, while the non-

Table 4. Factor loadings (i.e., eigenvalues) as determined by the principal components analysis. Factors with the highest eigenvalues explain most of the observed variance.

Factor	Eigenvalue	Percent of variance	Cumulative percentage
1	6.05	43.2	43.2
2	3.09	23.0	66.2
3	2.38	17.0	83.2
4	0.80	5.7	88.9
5	0.73	5.2	94.2
6	0.39	2.8	95.9
7	0.25	1.8	98.7
8	0.18	1.3	100.0

Table 5. Communalities (range 0.0–1.0) of 7 wing characters as determined by principal components analysis. Characters with lower communalities should partition the OTU's (populations) into more meaningful groups, i.e., they are most diagnostic.

Character	Communality
1) FWLE	0.94540
9) HWLW	0.91284
3) FWLW	0.75851
6) FDLW	0.73140
14) SUHW	0.68258
10) HDCL	0.61904
15) USGC	0.54793
13) DISC	0.21685

ordered color (DISC and USGC) and silver-spotting (SUHW) characters provide a more reliable means to discern groupings of OTU's. Figure 11 graphically represents the characters in relation to the second and third principal components.

The communalities (Table 5) indicate that most of the size characters are highly intercorrelated, i.e., in total they explain most of the observed variability. This is not surprising as 5 of the characters were continuous and displayed a wide range of variation. In contrast, characters DISC, USGC and SUHW have relatively low communalities, i.e., when combined with the other 5 characters, they explain a lesser proportion of the observed variance in the wing characters. As these only poorly correlate with any size characters, the PCA demonstrates that the three non-parametric characters, DISC, USGC and SUHW, are best at distinguishing the groups of OTU's. These results may be somewhat biased due to the non-parametric nature of qualitative characters. Nonetheless, other numerical taxonomic techniques confirm that characters DISC, USGC and SUHW can best partition the OTU's (Arnold, 1983, 1985).

Factor loadings of the first three principal components of each OTU were used to compute factor score for the 35 OTU's. Figure 12 depicts interrelationships of OTU's in the first three principal components and represents 83.2% of the variance in the original data matrix. The remaining 17% of the variance might modify positions of the OTU's as they are depicted in Figure 12. Based primarily on size characteristics, all green morphs (OTU's #22, 29–35) cluster together near the center of the plot. However, several morphs from the North Coast Range (OTU's #12, 14), South Coast Range (#2), Sierra Nevada (#16, 17) and Tehachapi Mountains (#23, 24, 26, 27) also lie in the same general area. Only the 3 *S. callippe juba* OTU's and the *S. callippe laura* OTU's (#18, 19, 20, 21) form a discrete cluster. *S. callippe callippe, S. c. comstocki,* and *S. c. liliana* OTU's (#1–12) are bisected by the cluster of green-morph OTU's. Thus the principal components analysis corroborates the finding of the discriminant function analysis that overall size is a useless character for distinguishing subspecies of *Speyeria callippe.* Qualitative characters such as DISC, USGC, and SUHW can better partition individuals into populations than size characteristics.

DISCUSSION

The description and explanation of variational patterns may be examined one character at a time or with many characters simultaneously. The trend in geographic variation studies has been from univariate and bivariate analyses to multivariate analyses (Gould and Johnston, 1972). Multivariate studies reveal not just correlations between characters, but correlations among suites of characters within the sampled populations.

My univariate and multivariate analyses of geographic variation, indicate that many of the characters previously used to distinguish subspecies of *S. callippe* are useless as taxonomic characters. This study, one on phenetic variation in nonordered state characters (Arnold, 1983), and another on the relationship of geographic variation in morphological and climatic variables (Arnold, 1985), demonstrate that most of the previously recognized subspecies of *callippe* are invalid based on the currently used characters. If subsets of OTU's derived via the univariate analysis are homogeneous for the characters in question, and there is a pattern to the variation, it should belong to geographically contiguous regions (Sneath and Sokal, 1973). Those sets of localities that are statistically homogeneous and geographically contiguous can be categorized as being biologically homogeneous and recognized taxonomically as subspecies. The univariate analysis demonstrates that the variation in 7 of the 8 characters is discordant. The pattern of variation in only one character, ventral disc color (DISC), correlates with geography and can be used as a basis for delimiting subspecies. Similarly, the multivariate techniques corroborate that DISC is the best character for partitioning populations, while the 5 continuous characters vary discordantly and the OTU's cannot be effectively grouped. DISC, USGC, and SUHW exhibit less variability, and thus can more effectively partition the populations. One advantage of PCA is that the relationships between the OTU's can be viewed without prior clustering, in this study, the grouping of populations into subspecies. Another important feature is that the trends in variability can be related to the actual characters which cause them (Moulton, 1973).

PCA has been used successfully in examining populations for phenetic intermediacy (Rising, 1968, 1970); however, since the technique does not maximize differences between biologically meaningful reference samples, it is not as powerful a tool for studies of hybrid or blend zones, or zones of abrupt phenetic transition as is discriminant analysis (Rohwer, 1972). Indeed, the discriminant analysis indicated that the previously recognized 16 subspecies were so poorly defined that only 43.2% of the individuals of unknown subspecific identity could be correctly identified based upon the same characters other lepidopterists have used to distinguish these "subspecies."

One of the major objections expressed by the opponents of the subspecies is that the trinominal system forces biologists to make arbitrary decisions that frequently distort the real nature of character variation and bias subsequent analysis (Hagmeier, 1958; Wilson and Brown, 1953). Also, most of the thorough studies of geographic variation show that independent characters vary discordantly in space (Gillham, 1956), in time (Doutt, 1955; Packard, 1967; Mason, 1964), and that single-character variation tends to be clinal (Sibley, 1954). As the environment exerts differing selective forces on differing characters one should expect that discordant variation will occur more frequently than concordant variation. The phenotypes thus assembled under the name of a subspecies might be so heterogeneous that the subspecies concept loses nearly all meaning. Often the only practical way to identify subspecies, such as those recognized by many butterfly taxonomists, is by geographic location. Yet this may obscure the true patterns of geographic variation in a species.

Statistical analyses of geographic variation have advantages over more subjective methods. They are repeatable, knowledge obtained subsequently can be incorporated, and are objective to the extent that they attempt to describe variation before partitioning into subspecies. A thorough character analysis can demonstrate that discontinuities are correlated with disjunct distributions or with abrupt changes in the environment. These qualities are all too often absent in systematic procedure at the infraspecific level.

Many subspecies have been based on too few characters, poorly chosen characters, or inadequate analysis of geographic variation of characters (Wilson and Brown, 1953). Diagnostic markings and other slight external characters of necessity serve as prime criteria for distinguishing museum specimens. Nevertheless, the objective of many describers of subspecies is to discern minute typological differences in samples of populations from different localities rather than to study the similarity of samples or variability within a population (Burt, 1954; Hubbell, 1954). The mere pigeonholing of populations at infraspecific levels, especially when the range of variation has not been ascertained for several characters, conveys a false impression of uniformity (Bogert, 1954). Subspecific names should be employed to designate recognizably different assemblages of populations within a species (Mayr, 1969).

Revision of the Subspecific Taxa of *Speyeria callippe*

Results of the several numerical taxonomic techniques employed in this study and others (Arnold, 1983, 1985), provide a basis for making taxonomic decisions at the infraspecific level. The 16 currently recognized subspecies of *Speyeria callippe* are reduced to 3 taxa: *callippe callippe* (Bdv.), *callippe nevadensis* (Edwards), and *callippe semivirida* (McDunnough).

Ventral disc color (DISC) is the best character for distinguishing the 3 subspecies. All populations with brown ventral discs, no matter what shade of brown, should be referred to as *S. callippe callippe.* These include silvered and unsilvered populations and those with several shades of brown scaling varying from reddish-brown to chocolate brown in color, and ranging from the Mt. Shasta–Trinity Alps region to San Diego, California.

Populations from southeastern Oregon, with greenish-brown or brownish-green ventral discs are grouped as *S. callippe semivirida.* All green disced populations from the east slope of the Sierra Nevada Mtns. and Great Basin are grouped as *S. callippe nevadensis.*

Most characters previously used are too variable to diagnose subspecies. These include general size, silver-spot pattern, spot color, dorsal melanization, dorsal ground color, and ventral margin banding characters (Arnold 1983, 1985). The revised taxonomy is as follows:

callippe callippe (Bdv.), 1852
  c. comstocki (Gunder), 1925 New Synonym.
  c. liliana (H. Edwards), "1876" (1877) New Synonym.
  c. elaine dos Passos and Grey, 1945 New Synonym.
  c. rupestris (Behr), 1863 New Synonym.

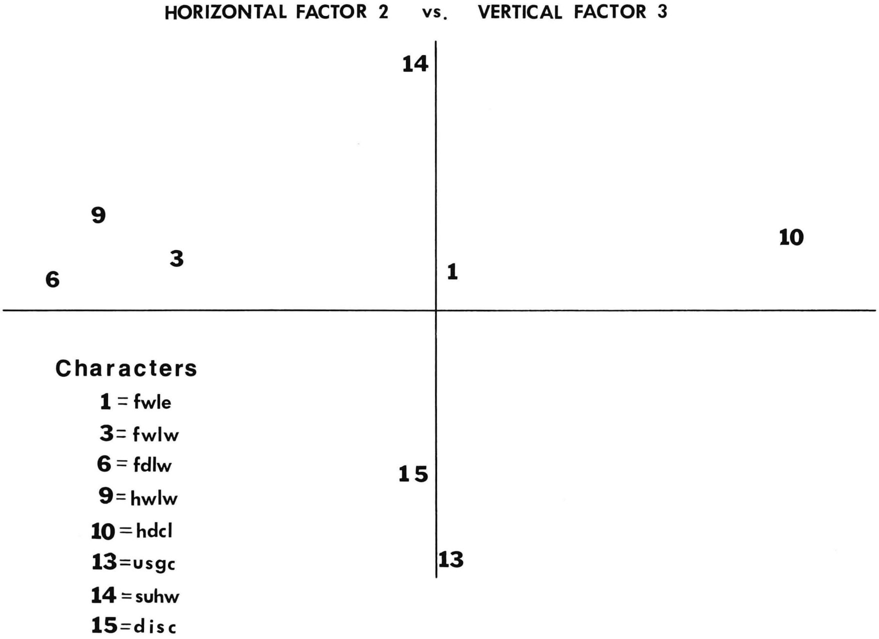


Figure 11. Graphic representation of principal components numbers 2 and 3 based upon characters FWLE, FWLW, FDLW, HWLW, HDCL, USGC, SUHW, and DISC. The underlying cause of horizontal factor number 2 is attributed to overall size, whereas vertical factor number 3 is largely due to wing coloration characters.

c. *juba* (Bdv.), 1869 New Synonym.
c. *laura* (Edwards), 1879 New Synonym.
c. *sierra* dos Passos and Grey, 1945 New Synonym.
c. *macaria* (Edwards), 1877 New Synonym.
c. *laurina* (Wright), 1905 New Synonym.
callippe nevadensis (Edwards), "1870–71" (1870)
c. *harmonia* dos Passos and Grey, 1945 New Synonym.
c. *meadii* (Edwards), "1872–73" (1872) New Synonym.
c. *gallatini* (McDunnough), 1929 New Synonym.
c. *calgariana* (McDunnough), 1924 New Synonym.
callippe semivirida (McDunnough), 1924.

Implications for Conservation

The San Bruno Mountain (San Mateo County, California) population of *Speyeria callippe callippe* was proposed for recognition as an Endangered Species by the U.S. Fish and Wildlife Service in 1978. Although the butterfly is no longer known from its type locality, San Francisco, Howe (1975) believed that the name *Speyeria callippe callippe* applied to the population at nearby San Bruno Mountain. Housing developments threaten to destroy a significant portion of the butterfly's habitat at this site. In 1978, the Endangered Species Act of 1973 could legally recognize invertebrates as Endangered Species at the population, subspecies, or species level. However, the Tellico Dam–Snail Darter controversy resulted

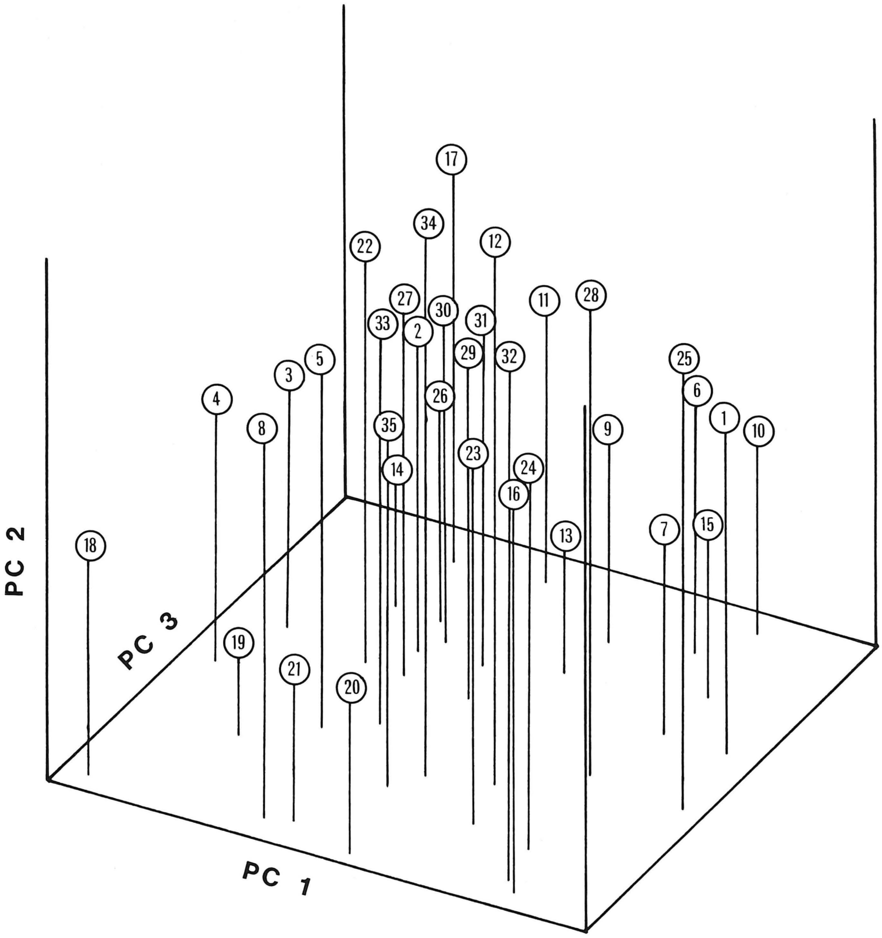


Figure 12. Three-dimensional plot of 35 *Speyeria callippe* populations based on the first three principal components. Labels PC 1, PC 2, and PC 3 on the axes refer to the first three principal components. Populations are coded as in Table 1.

in several amendments to the Endangered Species Act, including nomination of only formally named taxa, i.e., unnamed invertebrate populations could no longer be proposed for protection. Considerable ecological study of San Bruno Mountain *S. callippe* has been conducted since 1976 (Arnold, 1981; Reid and Arnold, unpubl. data). Although this population of *S. callippe* is no longer considered a distinct subspecies whose range is restricted to only San Bruno Mountain, it may represent a unique ecotype, similar to the situation recently elucidated by Murphy and Ehrlich (1980) for *Euphydryas editha* (Bdv.) in the San Francisco Bay Area. However, comparable ecological studies of other Bay Area *S. callippe* populations have not been completed.

SUMMARY

Univariate and multivariate statistical analyses of geographic variation in 8 wing characters of *Speyeria callippe* revealed that only one character, ventral disc color (DISC), can partition populations into meaningful groups. Other size and color characters used to differentiate previously recognized subspecies do not correlate with geography. These analyses provide a basis for revision of the subspecific taxonomy of *S. callippe.* The 16 previously recognized subspecies are reduced to three, whose morphology correlates with geography.

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Aleiodes sp. (Hymenoptera: Braconidae) Reared from an Anomalous Host, an Adult of the *Eremochrysa punctinervis* Species Group (Neuroptera: Chrysopidae)

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During the course of a study concerning the bionomics of some symbiote-using Chrysopidae (Insecta: Neuroptera) approximately 200 adults of a population belonging to the *Eremochrysa punctinervis* species group were collected in Gates Canyon, Solano Co., California. The adult chrysopids were attracted to mixed ultraviolet/visible lights between 23 April and 25 September during the summers of 1978–1980.

The newly collected adults were housed in Dixie® unwaxed 8 oz squat containers with clear plastic lids and were supplied with artificial honeydew (Johnson and Hagen, 1981, Nature, 289:405–407) and water. Although the containers were free of other insects and plant material, on 2 occasions solitary hymenopterous larvae were observed in the cartons within 2 days of the collection date. Unfortunately, only one was noticed before the dead adult chrysopids were removed from the carton. In this case, a female was found with a collapsed abdomen and an emergence hole behind tergite VIII. This larva died, but the other larva matured. The adult was identified as *Aleiodes* sp. (Hymenoptera: Braconidae). However, after the subfamily Rogadinae is revised, this species will not remain in *Aleiodes* (Shenefelt, pers. comm.).

The Rogadinae are known to parasitize only lepidopterous larvae (Krombein et al., 1979, Cat. Hymenop. Amer. N. of Mex., Vol. 1). Therefore, this would be a radical departure from the known host range of the subfamily. Still, it seems certain that the adult chrysopids were the hosts since there were no other insects in the cartons and the larvae were green, as would be expected if they had fed on the chrysopids. In addition, other Braconidae are known to parasitize a wide variety of insects and life stages, including adult Chrysopidae (Clancy, 1946, Univ. Calif. Pubs. Ent., 7(13):403–496; Krombein et al., 1979, Cat. Hymenop. Amer. N. of Mex., Vol. 1). So an adult chrysopid host would not be a major shift in the context of the family as a whole. However, it seems probable that this was merely a case of incidental parasitism of an atypical host. While the observed rate of parasitism was approximately 1% for *E. punctinervis* adults, many, apparently conspecific, adult wasps came to the mixed ultraviolet/visible lights. Therefore, it may be that the wasp normally parasitizes some lepidopterous larvae, but occasionally oviposits in chrysopid larvae. This could explain the apparent discrepancy between the low rate of parasitism observed and the abundance of adult parasites, and the emergence from an adult host, which is unusual for the Rogadinae.

I wish to thank Dr. P. A. Adams, Department of Biological Sciences, California State University, Fullerton, California 92634, for identifying the *Eremochrysa* and Dr. R. D. Shenefelt, 630 Oak St., Oregon, Wisconsin 53575, for identifying the *Aleiodes,* plus his comments on the classification of the Rogadinae.

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Myrmecomorphic Miridae (Hemiptera) on Mistletoe: *Phoradendrepulus myrmecomorphus*, n. gen., n. sp., and a Redescription of *Pilophoropsis brachypterus* Poppius

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Recent collections in Arizona have revealed a diverse and bizarre array of Miridae inhabiting desert mistletoe (*Phoradendron californicum*). Several myrmecomorphic forms are present, including a new genus and a species that has previously been described under two different names for the different sexes. In this paper, *Phoradendrepulus myrmecomorphus,* n. gen., n. sp. is described, *Pilophoropsis balli* Knight is placed as a junior synonym of *Pilophoropsis brachypterus* Poppius, and the female of *Pilophoropsis brachypterus* is redescribed.

All specimens treated herein are held in the Polhemus collection (JTP) unless otherwise noted.

Phoradendrepulus, NEW GENUS

Description.—Head broad, short, triangular as viewed from above; antennae long, slender, apical segments slightly thickened. Pronotum large, raised, quadrate; collar well defined; calli indistinct. Mesoscutum well exposed; scutellum sharply elevated, conical. Hemelytra short, brachypterous, coriaceous, barely attaining base of abdomen, posterior margins raised, rounded, clavus and cuneus indistinguishable. Abdomen constricted basally, globose posteriorly with conspicuous pleural fold. Legs long, slender; coxae and femora stout; length of tarsal segment 3 subequal to lengths of basal two combined; claws small, parempodia hair-like, pulvilli minute. Rostrum long, extending past hind coxae. Male genitalia of phyline-type; right clasper small, leaf-shaped (Fig. 1b); left clasper larger, cup-shaped (Fig. 1a). Overall body ant-like in form; both sexes brachypterous and very similar in general facies.

Discussion.—On the basis of pretarsal structure and form of the genitalia, *Phoradendrepulus,* n. gen. belongs in the subfamily Phylinae. It appears most closely allied to *Cyrtopeltocoris,* in particular the head shape, conical scutellum, and ant-like habitus are extremely reminiscent of *Cyrtopeltocoris* females. *Phoradendrepulus,* n. gen. may be separated immediately from other North American phylines by its unique ant-like form and brachypterous condition in both sexes, and by its large, quadrate pronotum.

Etymology.—The name *Phoradendrepulus* (m.) is derived from *Phoradendron,* the host plant genus, and *epulo,* Latin for feaster, alluding to the association of these bugs with mistletoe.

Phoradendrepulus myrmecomorphus, NEW SPECIES

Description.—*Brachypterous male:* Small, ant-like; length 2.48 mm; width across pronotum 0.76 mm; width across abdomen 1.12 mm.

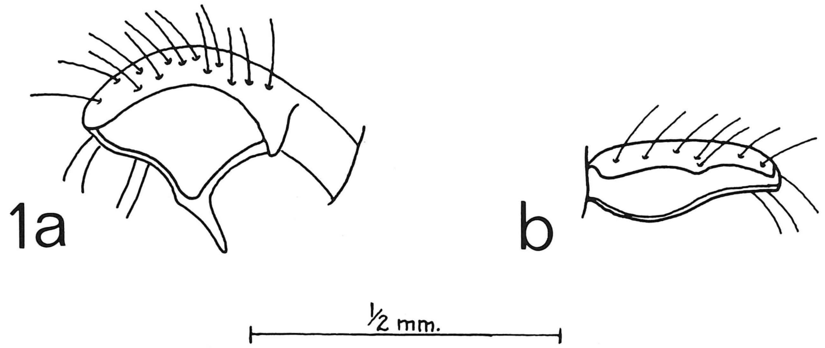

Figure 1. *Phoradendrepulus myrmecomorphus,* n. gen., n. sp., male genitalia. a. Left paramere. b. Right paramere.

Head dark brown, rugose; frons with transverse striae; a pair of stout setae present anteriorly between eyes; clypeus thickly set with fine gold hairs; vertex two times dorsal width of an eye, set with four stout dark setae; eyes reddish brown, anterior margins well separated from antennal sockets. Antennae brown; segment I short, stout, bearing three stout setae; segments II and III longer, slender; all segments clothed with short recumbent golden pubescence; lengths of segments I–IV (in mm): 0.24; 0.80; 0.64; missing.

Pronotum orange brown, raised, quadrate, posterior angles infuscated in some specimens; surface rugose, covered with very fine, short, upright, golden pubescence; calli indistinct. Mesoscutum broadly exposed, sloping downward posteriorly to scutellum; scutellum raised, conical, covered with fine gold hairs; a long seta present on each side of conical apex. Hemelytra orange brown, brachypterous, a small pallid area present centrally in some specimens; posterior margins upturned, smoothly rounded, barely attaining base of abdomen; surface with fine, recumbent gold hairs; several long setae present distad along hemelytral commissure.

Abdomen black, polished, shining, globose, basal segments constricted; dorsal surface with fine, recumbent gold hairs, intermixed with longer upright gold setae; pleural fold prominent basally.

Ventral surface orange brown; rostrum light brown, set with very fine, erect, short hairs; length 1.52 mm, reaching beyond hind coxae. Legs orange brown; fore coxae red, pallid basally, middle and hind coxae pallid; femora and tibiae clothed with fine recumbent gold hairs; tibiae set with stout spines; middle tibiae with a row of evenly spaced, fine, erect hairs on inner face; tarsal segment 3 as long as basal two segments combined. Venter of abdomen black, polished, set with numerous short, recumbent gold hairs and scattered long, upright hairs.

Male genitalia of phyline-type (see Fig. 1a, b); right clasper small, trough-shaped; left clasper larger, cup-shaped, with two spinose projections.

Brachypterous female: Generally similar to male in color and structure (see Fig. 2); stridulatory apparatus present. Length 2.88 mm; width across pronotum 0.80 mm; width across abdomen 1.28 mm. Lengths of antennal segments I–IV (in mm): 0.28; 0.84; 0.56; 0.48. Hind femora with sclerotized ridge (plectrum) on inside face of basal half, positioned to rub against microserrate costal margin of

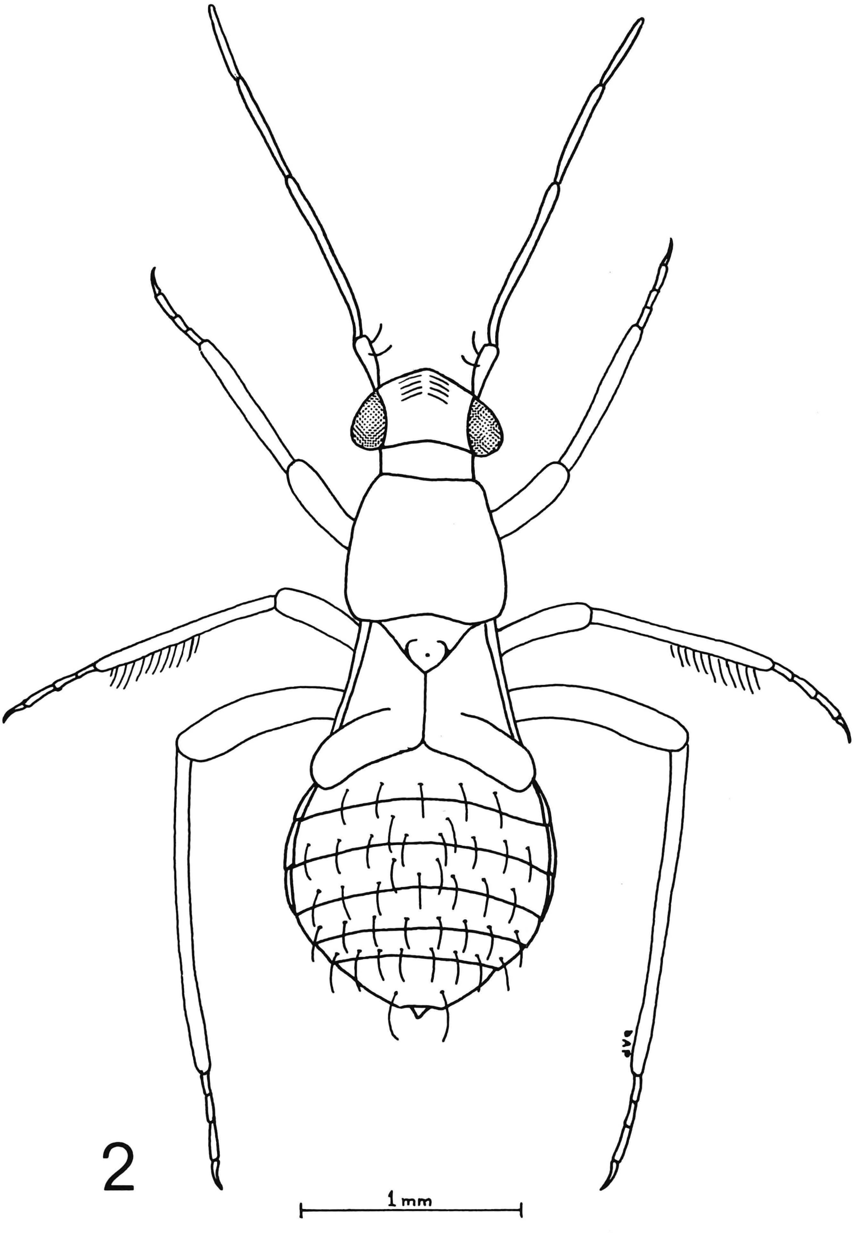

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Figure 2. *Phoradendrepulus myrmecomorphus,* n. gen., n. sp., adult female, dorsal view.

hemelytra (strigil). Ovipositor sheath long, extending caudad two-thirds length of abdomen to base of sternite 8.

Discussion.—Phoradendrepulus myrmecomorphus, n. sp. inhabits mistletoes (*Phoradendron californicum*) parasitizing mesquite (*Prosopis juliflora*). The insects are invariably taken in the company of myrmicine ants (*Crematogaster* sp.), and this, along with an exceptional ant-like habitus that makes the insects quite difficult to distinguish from ants in the field, suggests that the species is myrmecophilic. Another notable feature of this unusual mirid is a stridulatory mechanism consisting of a raised ridge located basally on the hind femur (plectrum) positioned to contact a striate costal margin on the hemelytra (strigil). The striations of the costal margin are very fine and difficult to see, and appear to be present only on the distal portion in the male.

The antennal proportions given in the description were taken from specimens having four segments on each side, however an unusually high percentage (25%) of the specimens in our small sample exhibit antennal oligomery. The antennal proportions of the specimens exhibiting oligomery are as follows:

			Antennal segment			
Sex	Date collected		I	II	III	IV
♀	X-13-82	L & R	1.2	3.8	2.9	—
♀	VIII-10-82	L	1.2	5.8	—	—
		R	1.1	4.0	missing	—

In the associated series of *Pilophoropsis brachypterus* collected from the same trees, only one specimen of 17 exhibited unilateral oligomery. Antennal oligomery is not an unusual phenomenon in Heteroptera (Leston, 1952), however the unusually high occurrence in *Phoradendrepulus myrmecomorphus* leads us to speculate that the extremely restricted habitat and mobility of these flightless insects has led to extensive inbreeding and further that this extensive inbreeding is the causal factor in the oligomery. The less frequent occurrence in *Pilophoropsis brachypterus* would consequently be explained by the greater interdeme gene flow permitted by the mobility of the macropterous males of the latter species. Of the dozens of mesquite trees sampled, only a few large trees had populations of these two species of myrmecomorphic bugs, and these were in general separated by a mile or more of harsh desert. Given the apparently restricted vagility of *Phoradendrepulus myrmecomorphus* individuals, gene exchange between local populations of this species is undoubtedly very infrequent.

Etymology.—Derived from the greek *myrmex,* ant, alluding to the ant-like habitus.

Material examined.—Holotype, ♂, and allotype, ♀: ARIZONA, Maricopa Co.: Ariz. Hwy. 87 at Verde River, Ft. McDowell Indian Res., VIII-10-82, J. T. Polhemus (JTP). Paratypes: 2 ♀, same data as type; 2 ♀, same locality as types, V-24-82; 1 ♂, 1 ♀, same locality as types, X-13-82 (all JTP).

Pilophoropsis brachypterus Poppius

Pilophoropsis brachypterus Poppius, 1914, Ann. Soc. Entomol. Belg., 58:249 (n. gen., p. 249; n. sp., p. 250).

Pilophoropsis balli Knight, 1968, Brig. Young Univ. Sci. Bull., 9:176. **New synonymy.**

Pilophoropsis brachypterus was originally described by Poppius from a brachypterous female specimen taken at "Hot Springs," Arizona. Knight, over 50 years later, examined several macropterous males from various localities in Arizona and described them under the name *Pilophoropsis balli.* One of us (JTP) has studied the types of both species at the USNM. A long series taken from

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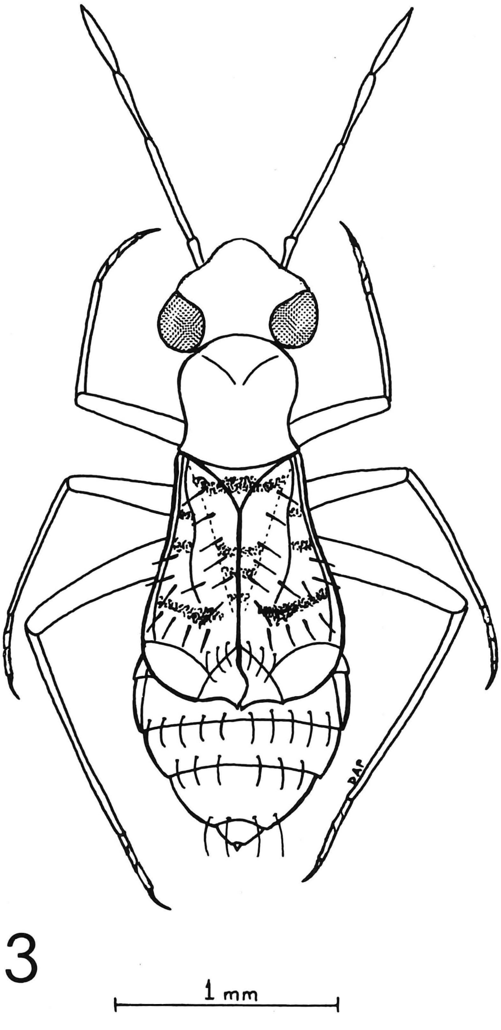

Figure 3. *Pilophoropsis brachypterus* Poppius, adult female, dorsal view.

mistletoe, *Phoradendron californicum,* at Ft. McDowell, Arizona, near Phoenix, now reveals that the two species are synonymous, with *P. balli* the junior synonym of *P. brachypterus.* Knight's 1968 description of the male, along with a figure of its bizarre genitalia, need not be repeated here, but a redescription of the female, in English, is provided to facilitate future identification of this unusual species. The insect is apparently confined to the Sonoran desert; to date no macropterous females have been found.

Brachypterous female: Small, ant-like (see Fig. 3); length 2.96 mm; width across pronotum 0.56 mm; width across abdomen 1.00 mm.

Head brown, shining, concave along posterior margin; width 0.76 mm; eyes small, not protrusive; vertex wide, equal to two times the dorsal width of an eye; frons smooth, set with fine gold setae; lora prominent, expanded. Antennae brown, segment I paler; segment I with a pair of stout setae; segments II–IV thickly set with short, stiff setae; segments III and IV thicker than segment II, subequal in thickness to segment I; lengths of segments I–IV (in mm): 0.20; 0.56; 0.36; 0.36.

Pronotum dark brown, shining, weakly campanulate, convex in side view; calli large, tumid, glabrous, with broad longitudinal sulcus between; surface covered with fine, short golden hairs. Scutellum dark brown, shining; anterior lobe upturned, almost vertical; posterior lobe flat, with a band of silvery, scale-like hairs running transversely across middle.

Hemelytra short, brachypterous, reaching only to posterior margin of tergite 4; dorsal surface brown, mostly dull, finely rugose, sparsely set with long, erect, bristle-like black setae; a transverse band of silvery, scale-like hairs across base of clavus joins a similar band on scutellum; two small patches of silvery hairs present anteriorly between costal and radial veins; another transverse band of silvery hairs present distad on corium near apex of clavus, broadly interrupted across clavus; clavus with three transverse bands of silvery hairs on apical half; cuneus dark brown, polished, with a patch of fine gold hairs present on posterior margin; membrane greatly reduced, dark brown, polished, inner margin rugulose.

Abdomen black, shining, rounded, sparsely set with fine, erect gold hairs; pleural fold present basally.

Ventral surface dark brown; rostrum length 1.12 mm, reaching between middle coxae; abdomen with fine recumbent gold hairs intermixed with longer, upright gold hairs; ovipositor sheath extending posteriorly three-quarters the length of segment 7. Legs brown; coxae, trochanters, and bases of femora pallid; set with short golden hairs, femora with a few longer hairs on posterior faces; tibiae with stout dark spines; terminal tarsal segment longer than preceding two taken together.

Records.—ARIZONA, Pima Co.: Tucson, IX-22-20, 1 ♂, E. D. Ball (USNM); Rincon Mountains, 1056 m (3300′), IX-2-38, 1 ♂, A. A. Nichol (USNM); Catalina Springs, IV-15, 1 ♂, E. A. Schwarz (USNM). Maricopa Co.: Ft. McDowell Ind. Res., Ariz. Hwy. 87 at Verde River, CL 1632, VI-2-81, 2 ♂, 1 nymph; VIII-10-82, 2 ♂, 4 ♀, 1 nymph; X-13-82, 1 ♂, 8 ♀; all J. T. Polhemus (JTP).

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The Life History of *Ophraella notulata* (F.) on Western Ragweed, *Ambrosia psilostachya* De Candolle, in Southern California (Coleoptera: Chrysomelidae)

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Despite an extensive and intensive survey of the phytophagous insect fauna of western ragweed, *Ambrosia psilostachya,* in southern California during 1968–1970, we failed to detect and hence did not include *Ophraella notulata* among the 130+ insect species reported from this widespread native plant (Goeden and Ricker, 1976c). However, while sweeping plants along Kitchen Creek at the southern end of the Laguna Mountains in San Diego Co. on October 17, 1979, we encountered this beetle on western ragweed from which it is now reported, presumably for the first time from California (Wilcox, 1965; Welch, 1978).

Distribution and host plants.—Wilcox (1965) listed *O. notulata* in North America from as far west as Arizona. Welch (1978) described its distribution as "... throughout most of the continental United States, parts of Canada ..., and as far south as Guatemala ..." exclusively on so-called "common ragweed," *A. artemisiifolia* (F.). He noted the apparent absence of common ragweed and *O. notulata* from southern California, the latter supposition based on our still valid, negative collection records from several other native ragweeds (Goeden and Ricker, 1974, 1976b). We also have collected eggs, larvae, and adults of *O. notulata* at Kitchen Creek from cocklebur, *Xanthium strumarium* L., a close ragweed relative, from which this leaf beetle is newly reported (Hilgendorf and Goeden, 1982, 1983). In the insectary, *O. notulata* additionally has been reared from egg to adult on potted plants of *A. chenopodiifolia* (Bentham) Payne, *A. confertiflora* De Candolle, *A. dumosa* (Gray) Payne, *A. eriocentra* (Gray) Payne, and *A. ilicifolia* (Gray) Payne. Apparently, none of these ragweeds is attacked by *O. notulata* in nature (Goeden and Ricker, 1975, 1976a, 1976b).

Biology.—The biology of *O. notulata* was studied in the field on western ragweed at Kitchen Creek during 1979–1982, and in the insectary of the Division of Biological Control, University of California, Riverside, at 27 ± 1°C, 40–70% relative humidity, and a 16/8-hr (light/dark) photoperiod. This supplements the study by Welch (1978) of *O. notulata* on common ragweed in Connecticut.

Egg.—Welch (1978) described the pyriform eggs (Fig. 1a) and illustrated the microscopic, hexagonal sculpturing of the chorion. Fifty eggs from our insectary culture measured 0.05 mm smaller in mean greatest width, but otherwise fit his description.

In insectary cagings, most fertile eggs were lightly, but firmly glued at their larger ends in clusters to the leaves of potted plants or bouquets of freshly excised branches. A few (<1%) infertile eggs also were found within these egg masses. Infertile eggs produced by unmated females and by older females towards the end of their oviposition periods were loosely scattered individually or in small, irregular clusters on the foliage and cage surfaces. Of 456 masses of fertile eggs examined, 296 (64.9%) were compact, elongate clusters (Fig. 1a); 91 (20.0%) were linear, single or double-ranked series; and 69 (15.1%) were loose, irregular clusters. Of 654 egg masses examined, 590 (90.2%) were laid on the undersides of leaves; the remainder, on the adaxial leaf surfaces. Many of the latter clusters were laid on leaves bent sharply upward or downward from their usual, nearly horizontal positions. Of 679 egg clusters examined, 212 (32.3%) were attached to a lateral lobe of a leaf alongside or straddled a primary vein, 143 (21.1%) were deposited on the terminal leaf lobe and commonly straddled the midrib, 57 (8.4%) were located in the angle of the midrib and a primary lateral vein, 44 (6.5%) were laid on a basal leaf lobe, and 4 (0.6%) were attached to a petiole wing. A simple experiment indicated that this egg placement partly was a response to gravity, as all 22 egg clusters laid on the leaves of 5 straight branches held vertically, but reversed 180°, were attached to the upside-down, adaxial leaf surfaces.

An average of 13.3 ± 0.2 (±SE) (range: 2–41) eggs were counted in 833 clusters recovered from insectary cagings. The distribution of eggs per mass was skewed such that only 41 (ca. 5%) of these clusters contained 23 or more eggs. Few fertile eggs were laid singly. Welch (1978) reported much larger masses averaging 36 eggs in his cagings.

Field observations on egg mass placement and size supported our insectary findings. At Kitchen Creek, 21 egg masses were found attached to the underside of cauline leaves located an average of 18 ± 1.7 (range: 5–35) cm below the apical, staminate inflorescences and 13 ± 1.6 (range: 0–30) cm above the lowest, living leaves on mature plants.

Larva.—Eggs hatched in 5 or 6 days in the insectary. The first instars emerged headfirst through irregular holes chewed in the chorions just below and lateral of the apical papillae (Fig. 1b). Larvae from the same egg mass usually hatched within a few hours of each other. Some masses apparently consisted of eggs laid by the same or different females on successive days. Embryonic development and hatching were delayed for a distinct segment of the eggs in such masses, which probably were artifacts of insectary culture. Eclosion took as little as 10 min. The empty chorion was abandoned and leaf feeding began as soon as 1 min after eclosion.

Welch (1978) reported head capsule measurements for each of the 3 instars. In insectary rearings of 21 isolated larvae on bouquets of fresh branch terminals, larval development lasted 12 ± 0.6 (range: 12–14) days. An average of 3.5 ± 0.1 (range: 3–4) days (ca. 30%) at the end of this period was spent as a nonfeeding prepupa in a coarse silk cocoon. This prepupal period averaged a day longer than Welch (1978) reported. On western ragweed, the first larval stadium lasted 4 days; the second stadium, 2–3 days; and the third stadium, 5–7 days. The larvae grew in length from 1.0–2.4 mm as first instars to 3.5–7.0 mm as third instars.

Feeding symptoms of the first instars were small "shot-hole" lesions in the nearer epidermis and mesophyll to, but not through, the opposite epidermis. This instar fed somewhat gregariously for a day or so, then began to disperse both upward and downward on the stems to feed as scattered individuals or in small groups. Molting, like feeding, usually occurred on the underside of a leaf, although some first instars fed and molted atop leaves. Second instars fed as scattered individuals and usually molted on the underside of leaves. Third instars skele-

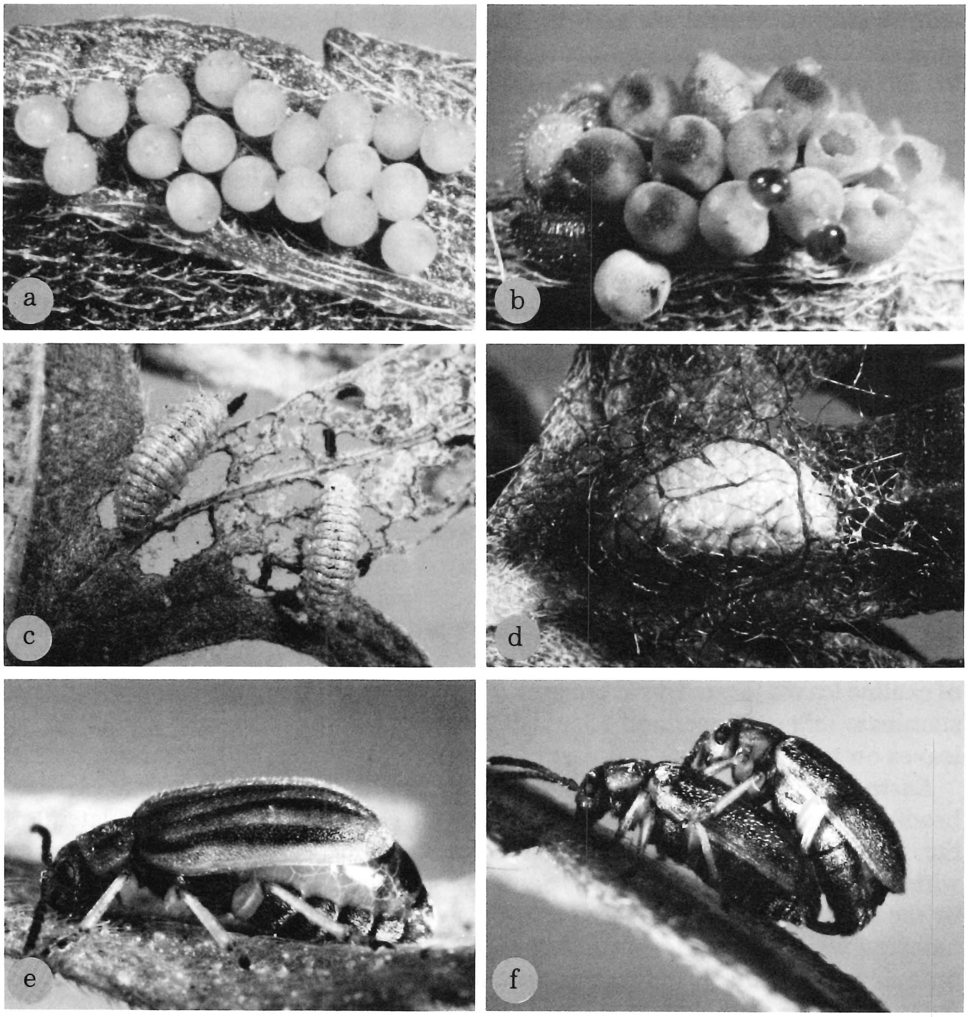

Figure 1. Life stages of *Ophraella notulata.* (a) Egg mass, 13×. (b) Newly hatched larvae, 17.3×. (c) Third instars and feeding damage on leaf of western ragweed, 4.1×. (d) Cocoon containing prepupa, 6.7×. (e) Gravid female, 8×. (f) Adults *in copula,* 6.8×.

tonized the leaves from the upper and lower surfaces and left the midribs, primary lateral veins, and opposite epidermis largely intact (Fig. 1c). Dark brown-black, subcylindrical, fecal pellets littered the foliage upon which the larvae fed, the foliage beneath, as well as the cage floors. Unlike Welch (1978), we observed no tendency for the larvae to migrate at dusk toward the terminal growth of potted plants caged either in the insectary or in a sunlit greenhouse.

The fully grown third instar usually began construction of its cocoon away from feeding areas on the upper surface of a leaf along and over a midrib or a lateral vein. Cocoon formation was initiated at various times of the day and night and continued to completion during both the photophase and scotophase. The first step in cocoon formation was the stringing of several, transverse, silk strands between the leaf or leaf lobe margins across the larval dorsum. Contrary to Welch (1978), who reported the silk to be a "maxillary secretion," we found it to issue as a clear, viscous liquid from an opening on the prosternum between the fore coxae. The gland orifice is a narrow, circular, sclerotized ring that appears two-lipped when closed. The head of the larva periodically dipped postero-ventrally as it secured additional mouthfuls of this secretion. The thoracic sterna and coxae shone from a coating of the secretion. The freshly formed, clear, silk strands darkened to golden yellow, then to reddish brown. After several transverse strands were laid, the process began of joining them with other strands and connecting these to the leaf surface and margins. The strands from which the cocoon was fashioned were irregular in length and diameter and formed an open meshwork through which the contents could be seen (Fig. 1d). Strands were thickened (1) by running a single strand between the mouthparts while depositing a coating of the secretion, (2) by coating in a similar manner 2 or more strands held together with the mouthparts, and (3) by incorporating plant hairs broken or chewed from the leaf surface into the strand coating. The fore legs and mouthparts were used to manipulate the strands while spinning. The surface of the leaf upon which the cocoon was formed was kept relatively free of silk and rubbed smooth by the body movements of the larva. The larva moved actively about within the cocoon under construction by adhering to the leaf surface with its posterior, ventral "proleg" or by grasping the webbing from inside with its middle and hind legs. Turning itself end-over-end, the larva arched its dorsum upward against the forming cocoon and thus used its body as a template to shape this structure. The larva rested periodically during cocoon formation and these resting periods became longer as the cocoon neared completion. The finished cocoon (Fig. 1d) had a flattened teardrop shape inside that was roughly twice the width and one and a half the height of the larva. Externally, the cocoon lay appressed to the leaf surface and tapered at one end to a semicircular opening; the other end was rounded and closed inside, but flared outward externally. One larva was observed to take 7½ hr to complete its cocoon.

Pupa.—Prior to pupation the larva partially backed out through the open mouth of its cocoon and voided a pile of dark, liquid feces on the leaf surface. Molting subsequently occurred inside the cocoon, where the cast exuviae usually was deposited behind the exarate pupa at the inner mouth of the cocoon. The pupal stage of 19 individuals averaged 4 ± 0.1 (range: 3–4) days in the insectary.

Adult.—The adult (Fig. 1e, f) was described in detail by Horn (1983). Welch (1978) illustrated an adult in dorsal view and the terminal, abdominal, sternal characters useful in separating the sexes.

Beetles emerged from cocoons through holes usually chewed in the end opposite the cocoon opening, but occasionally exited through the top or at the same end as the opening. Like Welch (1978), we noted that adults emerged only during the photophase. Depending on the generation involved, the emerged adults feed on leaves, mate, and either reproduce or overwinter as discussed below. Also like Welch (1978), we noted that mating could occur within 1 or 2 days after beetle emergence in the insectary.

All of 6 females individually reared from eggs in the insectary initially oviposited 5 days after they had molted to adults within their cocoons. Each of 21 mating pairs collected at Kitchen Creek on October 17, 1979, were caged separately with an excised branch of western ragweed which was checked for eggs and replaced daily during the oviposition period of each female. These beetles normally would have overwintered and not have reproduced until the following summer; however, after feeding under insectary conditions, the females began to oviposit in an average of 9 ± 1 (range: 3–21) days. Fourteen of the 21 females that subsequently were not accidentally killed or escaped laid an average of 667 ± 60 (range: 385–1206) eggs during a 66 ± 6 (range: 32–106) day oviposition period. Based only on the days when they oviposited, an average of 45 ± 4 (range: 25–67) days each, these 14 beetles laid 15 ± 0.4 (range: 1–57) eggs daily. These females were observed *in copula* (Fig. 1f) an average of 5 (range: 3–11) times and lived an average of 9 (range: 1–14) days after they ceased oviposition. The 16 males that did not die prematurely or escape lived 151 ± 14 (range: 83–260) days after they were collected; the 14 females that oviposited lived 83 ± 7 (range: 42–123) days after they were collected.

Seasonal history.—*Ophraella notulata* is multivoltine in southern California. The beetles overwinter as mated adults, which Welch (1978) also reported from Connecticut. The earliest date that we swept beetles from vegetative shoots of western ragweed at Kitchen Creek was June 17. The leaf beetle was readily cultured in glass-topped sleeve cages as described by Gilstrap and Goeden (1974) on potted western ragweed, which itself is readily propagated vegetatively. Under insectary conditions, *O. notulata* completed a generation each month under continual culture for 27 generations. *Ophraella notulata* probably produces at least 3 generations annually at Kitchen Creek. The last generation, developing on mature plants in October and early November, was most numerous. Distribution of immatures and adults was patchy in 1981, but quite uniform in 1982, judging from sweep net samples along the margins of Kitchen Creek.

Mortality factors.—No parasites were reared from egg masses collected in the field. Egg predation by a large, red mite (Acarina: Anystidae) was observed. Partly and wholly collapsed eggs were commonly collected at Kitchen Creek. Larvae were fed upon by nymphs and adults of *Perillus splendidus* (Uhler) (Hemiptera-Heteroptera: Pentatomidae) in the field. *Chaetonodexodes vanderwulpi* (Townsend) (Diptera: Tachinidae) was reared as a solitary, endoparasite from prepupae collected in cocoons.

Acknowledgments

Ophraella notulata was identified by Dr. T. N. Seeno, Insect Taxonomy Laboratory, California Department of Food and Agriculture, Scaramento. Dr. J. A. McMurtry, Department of Entomology, University of California, Riverside, identified the anystid mite. Dr. D. Wilder, Systematic Entomology Laboratory, IIBIII, % U.S. National Museum of Natural History, Washington, D.C., identified the "very interesting and uncommon tachinid."

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PAN-PACIFIC ENTOMOLOGIST
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Scientific Note

Description of the Previously Unknown Male of *Ophrynon levigatus* Middlekauff (Hymenoptera: Symphyta, Orussidae)

Recently Dr. Henry A. Hespenheide[1] sent me two Orussidae for identification. These had been collected at different times and localities in connection with his studies of the ecology and taxonomy of Buprestidae. One submitted specimen, a male, is the previously unknown opposite sex to the recently described unique female, the holotype of *Ophrynon levigatus* Middlekauff. The second orussid specimen was an unrelated new genus and species from Panama.

The male specimen emerged from wood of *Quercus dumosa* Nutt. collected by D. S. Verity, April 2, 1978 at 3500′ elevation in the Santa Rosa Mountains, Riverside County, California. The scrub oak wood was being held in a cage for insect emergence, and the following Buprestidae came from the same collection which produced the male *levigatus*: *Acmaeodera knullorum* Barr; *A. linsleyi* Cazier; *A. vulturi* Knull; *Acmaeoderopsis guttifera* (Le Conte); and *Hesperorhipis jacumbae* Knull. Verity thought that due to their larger size, one of the *Acmaeodera* would most likely be the host of the orussid.

The holotype female was described (Middlekauff, 1984) from a specimen collected April 3, 1956 at Brawley, Imperial Co., California.

Ophrynon levigatus Middlekauff

Plesioallotype male.—Length 5 mm. Head, antennae, and abdomen black. Knees (apices of femora), outer faces of tibiae (Fig. 5), and a spot on lower apical portion of stigma whitish (Fig. 1). Basal two-thirds of femora, and undersides of tibiae dark amber. Tarsi somewhat lighter amber. Fore wing clear, lacking a pale band below the stigma. Venation as in Figure 1. Apical veins of the wing beyond M (forming base of discoidal cell) and a cu-a clear, hardly discernible. Cross vein 2 r-m appears to be absent, but in good light is seen to extend but half way across the base of cell $2R_s$. Veins in the hind wing, Figure 2, except for the base of R, are, if present, so faint as to be indiscernible.

Facial carinae not as pronounced as in the female, but present and enclosing the frons (Fig. 4). A low, faint carina bisects the frons as shown in the female. Each shallow pit on the face bears a single, small seta and the area between the facial pits is smooth and shiny. Postocular carina and surrounding area similar to female. Legs similar. Scutellum with similar pits, but lacks the anterior notch. Hind femur swollen (Fig. 5) slightly more than 2.5 times longer than broad. Hypopygium as shown in Figure 3.

The specimen is in the collection of the California Academy of Sciences, San Francisco, California.

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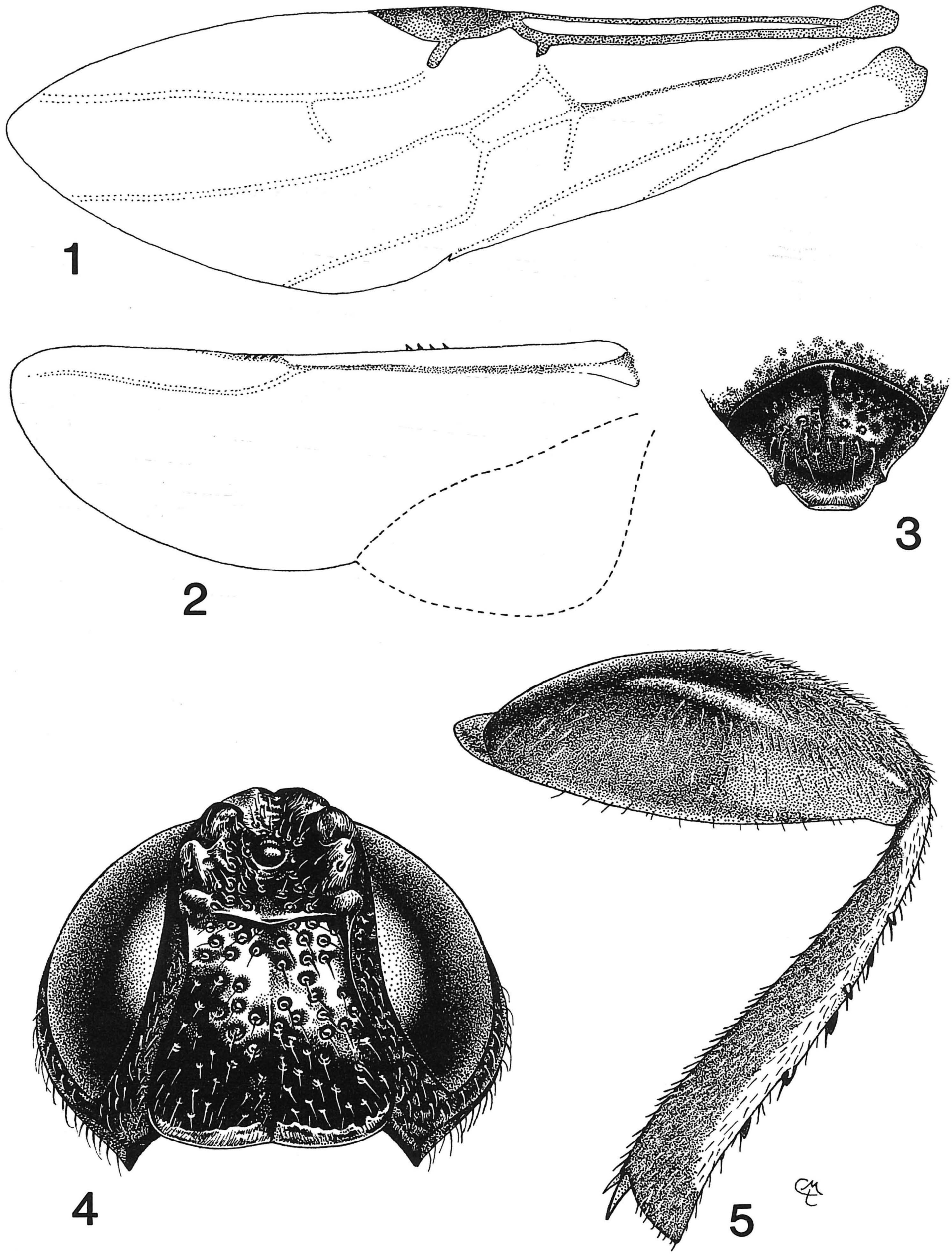
[1] Department of Biology, University of California, Los Angeles, California.



Figures 1–5. *Ophrynon levigatus* Middlekauff, plesioallotype, ♂. Fig. 1. Forewing. Fig. 2. Hindwing. Fig. 3. Hypopygium, ventral view. Fig. 4. Head, frontal view. Fig. 5. Hind femur and tibia, lateral view.

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Scientific Note

Occurrence of the Cotoneaster Webworm, *Athrips rancidella,* in California (Lepidoptera: Gelechiidae)

The Palearctic moth, *Athrips rancidella* (Herrich-Schaeffer), is widespread in Central and South Europe and occurs in Turkmenia, S.S.R., presuming the synonymy to be correct (Sattler, 1968, Dt. Ent. Zeit., N.F., 15:115; 1978, ibid., 25: 59). Its larvae feed on Rosaceae: *Cerasus, Cotoneaster,* and *Prunus,* according to records for its synonyms (Spuler, 1913, Kleinschmett. Europas, 361; Schutze, 1931, Biol. Kleinschmett., Verlag Int. Ent. Verein, 116; Busck, 1934, Proc. Ent. Soc. Wash., 36:82; Kuznetsov, 1960, Akad. Nauk SSR, Trudy, 27:34). This species was discovered at Portland and Eugene, Oregon, in 1929, and had been recorded at several sites in northern Oregon and at Vancouver, Washington, by 1934 (Roaf et al., 1937, J. Econ. Ent., 30:134). In the Pacific Northwest, larvae were found on *Cotoneaster horizontalis,* a deciduous, ornamental shrub that originated from China; and the adventive population was described as *Cremona cotoneastri* by Busck (1934, loc. cit.), in the belief that it was an undescribed species introduced from the Orient. Subsequently this moth has been collected in coastal British Columbia, Washington, and Oregon (USNM records; Hodges, in litt.).

Larvae of *A. rancidella* were found in Berkeley, California, on *Cotoneaster congesta,* by L. E. Casher and R. F. Gill, students in our Immature Insects course, in early May 1983. *C. congesta,* which is sometimes known as *C. microphylla* var. *glacialis,* is a low-growing Himalayan shrub with dense foliage, superficially resembling *C. microphylla,* and both are popular evergreen ornamentals. Another collection of larvae and pupae, made May 13, produced adults from May 17 to June 23 (JAP 83E50). Subsequent surveys of several other species of *Cotoneaster* in the vicinity did not reveal presence of the conspicuous larval damage. *C. congesta* is not a commonly used ornamental in Berkeley; *C. lactea* (=*Parneyi*) and other slender, arching species with sparse, tomentose leaves are much more abundant, at times weedy, but evidently are not selected by *A. rancidella.*

According to Roaf et al. (1937, loc. cit.) the insect is univoltine, and young larvae spend the winter in silken hibernacula on the branches. In Berkeley, most of the feeding occurred in spring, when the black larvae covered the branches with dense silken webs, from which they foraged, encompassing the entire foliage. Feeding primarily was skeletonizing of the leaf surfaces, so that the whole shrub became a caked mass of silk, frass, and brown leaves. By late July the plant showed evidence of recovery, with green foliage distally, and no larvae were discovered feeding on the new growth.

In 1984, another colony was discovered in Berkeley, by Ward Russell and W. W. Middlekauff. Larvae caused similarly conspicuous damage on the same ornamental shrub, and moths emerged in late May and the first week of June (JAP 84E126). The second site is about 1.0 airline km east of the first, at a higher elevation.

I thank R. A. Beatty, Dept. Landscape Architecture, U.C. Berkeley, for information on the cotoneasters, and R. W. Hodges, Systematic Entomology Labo-

ratory, U.S. Department of Agriculture, Washington, D.C., for identification of the moth and literature references.

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Life History and Biology of *Pyrausta orphisalis* Walker (Lepidoptera: Pyralidae) on Mint in Washington[1]

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Abstract.—*Pyrausta orphisalis* Walker is a foliage feeder of spearmint and peppermint in Washington during its larval stages. Three generations occur per year, with typically five larval instars per generation. The life history of each generation is illustrated and various biological data are provided, viz., information on flight behavior, mating, adult longevity, ovipositional behavior, fecundity, immature development, larval habitat, feeding damage, overwintering, and natural enemies.

Pyrausta orphisalis Walker is a small (wing span, 14–16 mm), distinctive, orange and brown day-flying moth, which according to Munroe (1976) occurs along Canada's southern tier from Newfoundland to the Fraser Valley of British Columbia, south to northern Florida, the Sierra Blanca of New Mexico, Sonoma and Modoc counties, California. The moth frequents commercial mints [Scotch spearmint (*Mentha spicata*), native spearmint (*M. cardiaca*), and peppermint (*M. piperita*)] for nectar and oviposition, and at times, may be observed by the hundreds in flight in the field. Population levels will vary from year to year and between areas in Washington. The larvae feed on mint foliage and have been considered economically important on occasion by growers.

Descriptions of the life stages of *P. orphisalis* have been reported previously (Walker, 1859; Munroe, 1976; Campbell and Pike, 1984), but little information has been published on the life history or biology of the insect. Frick (1961) mentioned that there appear to be three generations a year, that the larvae feed on the terminal growth of mint, and that adults are sometimes extremely numerous in August. The purpose of our study was to document the life history and basic biology of *P. orphisalis*. Our principal objectives were to determine 1) the number of generations per year and seasonal occurrence of each, 2) mating behavior, oviposition, and fecundity, 3) larval behavior and feeding damage to mint, 4) the developmental times for immatures, 5) the overwintering stage, 6) adult flight behavior and longevity, and 7) the natural enemies of *P. orphisalis*. Voucher specimens are on deposit at the Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, Washington.

MATERIALS AND METHODS

Field and laboratory studies were conducted over a 2-year period (1981–1982) at the Washington State University, Irrigated Agriculture Research and Extension

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[1] Scientific Paper No. 6491, Washington State University, College of Agriculture Research Center, Pullman. Project 4412. This research was made possible in part by funds provided by the Washington Mint Commission and the Mint Industry Research Council.

Center, Prosser. Where practical, observations and studies of *P. orphisalis* were carried out on mint under cultivated field conditions. It was often necessary, however, to observe the same individuals over time, which required the use of cages or containers to confine the insect. For the field, cylinder cages (15-cm diameter, 30-cm height), constructed of cellulose-nitrate plastic and vented at the top with saran screening (400-μm mesh), were employed unless stated otherwise; for the laboratory, clear plastic (5-cm diameter, 2-cm height) or glass (5-cm diameter, 2-cm height) petri dishes or cylinder cages (15-cm diameter, 30-cm height, 2.5 × 2.5-cm wire mesh covered with plastic wrap) were used. All adults and immatures observed in the laboratory were held or cultured under a light and temperature regime of 16/8 hr (light/dark) and 23–28°C/20.5°C, respectively.

The general life history and habits of *P. orphisalis,* including the occurrence in time of its different life stages and number of generations per year, were determined on the basis of near-daily (May to September) or weekly (April, September to mid-November) field observations and sampling of spearmint and peppermint. Mint cuttings, sampled randomly from the field, were usually viewed with a hand lens or binocular microscope to detect eggs and distinguish first and second larval instars; third, fourth, and fifth instars, prepupae, pupae, and adults were discernible without magnification. The overwintering stage of *P. orphisalis* was determined by periodic inspection (October through February) of caged mint, stocked heavily in late August with second generation adults (100+/cage, two cages used, each 1.0 × 0.5 × 0.5 m).

Mating, ovipositional period, and fecundity were studied using virgin females paired with males held on mint under laboratory cage, or on mint leaves in petri dishes. Fecundity was also assessed on the basis of eggs dissected from virgin females, reared from collected ultimate instars previously held for ca. 1 week on caged mint in the field. Egg placement on the plant was determined by field observation, and systematic sampling and evaluation of mint cuttings. Egg eclosion and mortality were evaluated from eggs on mint in the field and the laboratory.

The developmental times for immatures were determined mainly from laboratory studies. The feeding sites and habits of each instar were determined through field observation, as were data on pupation.

Parasitoids were reared from host larvae in the laboratory and subsequently identified by specialists (Table 1). Predator information was derived from field observations.

RESULTS AND DISCUSSION

There were three generations of *Pyrausta orphisalis* that developed annually in Washington. The life history of each is illustrated in Figure 1. The overall generation times (in terms of length) were quite similar for the first two generations, but substantially longer for the third. Similarly, field developmental times, in terms of equivalent immature life stages for the first and second generations, as well as the egg, first, second, and third larval instars of the third generation were quite comparable; the fourth and fifth larval instars and prepupa of the third generation, however, required more time to develop than their earlier equivalents, perhaps due to cooler seasonal temperatures. There was overlap in life stages within and between generations, particularly during the summer (Fig. 1). Nonetheless, there were peak periods of abundance for each life stage in each generation,

Table 1. Parasitoids of *Pyrausta orphisalis* Walker in Washington reared from field-collected host larvae, Prosser, 1981–1982.[1]

P. orphisalis instar	No. reared	No. parasitized	% parasitized	% of total parasitization *P. spinator*[2]	*Cotesia* sp.[3]	*M. campestris*[3]	*S. bilineatus*[2]	Unknown tachinid sp.[4]
I	50	1	2	100	—	—	—	—
II	81	3	4	100	—	—	—	—
III	191	20	10	75	20	5	—	—
IV	218	48	22	71	23	6	—	—
V	384	43	11	78	10	10	1	1
Total or $\bar{x}$	924	115	12	74	17	7	1	1

[1] Identification of Ichneumonidae by Drs. J. R. Barron and J. E. H. Martin, Biosystematic Res. Instit., Agric. Canada, Ottawa, Ont., Canada; Braconidae by Dr. P. M. Marsh, Systematic Entomology Lab., USDA, Beltsville, Md.

[2] Hymenoptera: Ichneumonidae.

[3] Hymenoptera: Braconidae.

[4] Diptera: Tachinidae.

e.g., first generation, first instar larvae in 1982 were most prevalent during the first week in June, though some were present before and after that date. Overwintering by the third generation prepupa began in October or November, followed by pupation in April or May, and finally adult emergence in May.

The moth is diurnal; white/blacklight traps operated nightly (concurrent with peak daytime flight periods) yielded negative results. Striking orange and brown coloration made the moth distinctive in the field coupled with its characteristic short, often jerky, rapid flight. The moth seldom ventured far from mint fields, usually staying just above or within the mint's upper canopy. Between flights, short resting periods by the moth commonly occurred on the undersides of mint leaves. Sound perception in adults was acute; a camera's shutter click was sufficient to cause resting moths to take flight. Both sexes of the first two generations took nectar from mint flowers during daylight hours.

Mating was observed only in the afternoon and at dusk in the field. Periodically, large field aggregations of males (up to 100 estimated) were observed in flight around a female, or in flight near a mating pair usually hidden in mint foliage, suggesting the female released or used a sex pheromone to lure males. Males in aggregations, were observed with external genitalia extended. In the laboratory, once a male and female were paired, mating occurred within a period of a few hours to about 3 days, preceded by presumed calling of the female resting upside down from a plant or container and with its antovipositor extended. Copulation, which can last for nearly an hour, was initiated immediately upon approach by a male to a stationary female. During union, moths faced in opposite directions and generally moved about short distances. Mating occurred during the same day as emergence or anytime within the first 6 days following emergence.

Initial oviposition commenced generally two days after mating and lasted from 1 to 6 days, $\bar{x} = 3$ ($n = 8$). Fecundity, based on laboratory studies, was extremely variable ranging from 1 to 196 eggs, $\bar{x} = 115$ ($n = 9$). We also observed that unmated females deposited a few eggs. Dissected virgin females contained 17 to 75 mature eggs, $\bar{x} = 35.4$ ($n = 30$).

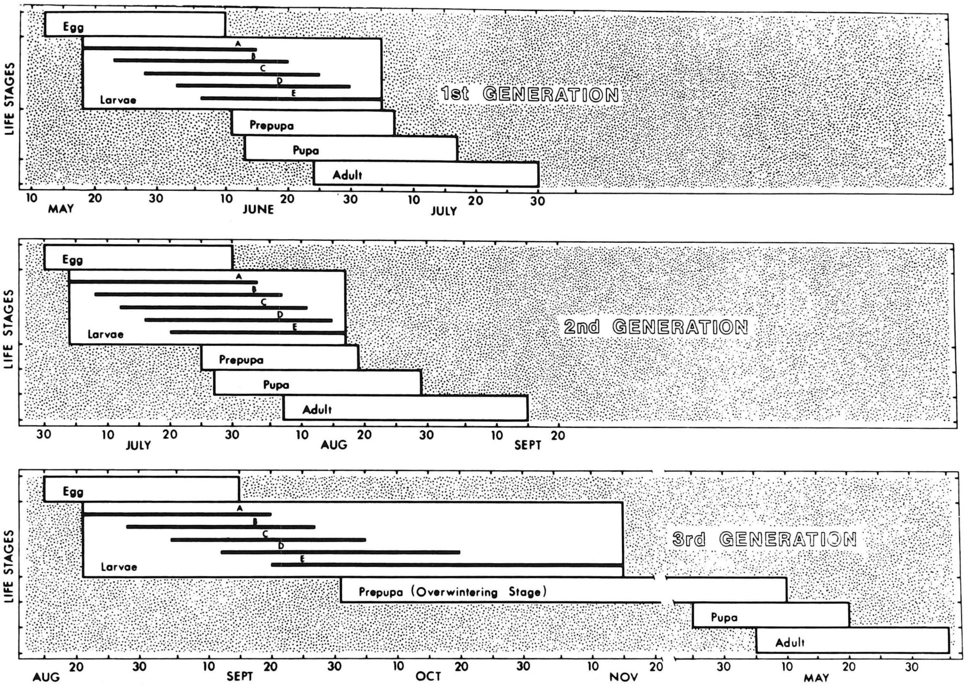

Figure 1. Life history and generations of *Pyrausta orphisalis* Walker in central Washington, 1981–1982 [n (2-year, 3-generation totals) = eggs, 719; larvae, 1717; adults, 3063].

Females lit frequently to oviposit in the field, usually depositing eggs singly, but occasionally in clusters of two to three. If four or more eggs occurred at one site on the plant, it was due to separate visits by the same or different moths. Females typically probed prospective sites with their antovipositors prior to egg deposition. Eggs ($n = 719$) were usually laid on leaf buds, small leaves subtending the buds, among flowers, and less frequently, on larger terminal leaves or stems. Interestingly, egg mortality appeared to be related to ovipositional site; egg mortality on larger leaves and stems reached ca. 60% ($n = 128$), while mortality for those among small terminal leaves and flowers was only 5% ($n = 509$). The appearance of unhatched eggs included partial clearing, collapse, color change to yellow or orange, no development, or partial development but without eclosion. In the laboratory, eggs hatched in ca. 4 days. The stemmata of the pharate larva became visible after 3 days and the head capsule darkened on the fourth.

Developmental time from egg to adult was temperature dependent; for larvae ($n = 70$) reared in cohorts at 28°C/20.5°C (16/8 hr, light/dark) in the laboratory, the mean was 32 days. For individually cultured larvae ($n = 17$) at 23°C/20.5°C (16/8 hr, light/dark), the mean was 38.5 days. Under July–August field conditions, the average total time was 34 days ($n = 70$). There were five larval instars in each generation. Based on laboratory studies, the stadia of the first four instars were ca. 4 ($n = 50$), 3.5 ± 0.7 ($n = 29$), 3.5 ± 1.1 ($n = 27$), and 4.0 ± 1.2 ($n = 24$) days, respectively. The fifth instar had two distinct phases, an actively feeding green-phase which lasted 5.3 ± 1.3 ($n = 24$) days, followed by a nonfeeding brown-phase which lasted 1.8 ± 0.6 ($n = 24$) days. The prepupa and pupa lasted 1.7 ± 0.6 ($n = 19$) and 10.7 ± 0.6 ($n = 17$) days, respectively. Although five instars were typical, a sixth (male or female) occurred occasionally (Campbell and Pike, 1984). In such cases, the third and fourth instars lasted about 1 extra day, a green-phase fifth about a day shorter, followed by a green-phase sixth lasting about 5 days; the remaining stages were comparable to the "typical" individual. Since the sixth instar was uncommon it was not included in Figure 1. Adults used for studying fecundity lived 6 to 13 days, $\bar{x} = 9$ ($n = 13$). Virgin females, however, lived as long as 21 days.

Since eggs were usually laid singly, larvae were usually found one per branch terminal, but two to three were fairly common. Following eclosion, first instars bored into leaf buds or fed among the small subtending leaves. Feeding damage by the first instars was noticeable only with close inspection. Some peppermint plants showed a slight chlorosis at or near the point of feeding. First instars often inhabited and fed individually within single flowers making them difficult to detect. Prior to moulting, first instars constructed single loose-weave silk shelters in the bud or in the leaves directly below the bud. Ecdysis took place in the shelters followed by about one day of inactivity by the new larvae. The exuviae were usually consumed by the larvae.

The second instar was often found in the same locations on the plant as the first, except not usually inside the flowers. It often hid among the flowers and fed on the calyxes, or the basal aspects of the leaves. Third instars typically occurred among small leaves subtending the bud or among larger leaves. These larger leaves were often silked together by the larvae. Damage by this instar consisted of chewing holes or removing upper leaf tissue in transverse bands at mid-leaf, causing leaf dieback distal to the feeding. Leaves tied together by silk occurred not only with the first three instars, but also the fourth and fifth. These silked together leaves served not only as ecdysial shelters, but also retreats on and in which larvae fed. It was not uncommon for a single individual during feeding and development to construct several shelters. Fourth and fifth instars clearly caused the most plant damage. These latter instars were highly active and moved freely through the crop canopy, often feeding on several plants. Feeding ceased with the brown-phase fifth instar, which would leave the plant to construct pupal shelters on the soil. The shelters consisted of fallen mint leaves or soil particles silked together. Adults emerged through the proximal end of the pupal shelters.

A number of natural enemies were found associated with *P. orphisalis.* The reared parasitoids included ichneumonids, braconids, and a tachinid (Table 1). *Pristomerus spinator* Fabricius (Hym., Ichneumonidae) was the most predominant in the rearings. It parasitized commonly third through fifth instars, rarely first or second. Initial parasitization probably began with thirds, since they were the first to venture into the more open, vulnerable microhabitats. The host generally reached the pupal stage before death and eventual consumption by the parasitoid. *Cotesia* sp. (Hym., Braconidae) was about one-fifth as prevalent as *P. spinator.* It also attacked third through fifth instar larvae, but differed from *P. spinator* in that it caused death in the host earlier, generally by the fourth or fifth instar. *Cotesia* sp. pupated in a self-spun cocoon within a feeding shelter, but outside its host. *Meteorus campestris* Vier (Hym., Braconidae), a less abundant parasitoid than *Cotesia* sp., attacked third through fifth instar larvae and caused death to the brown-phase fifth. Generally, the fifth completed its pupal shelter before death. Only single specimens of *Stictopisthus bilineatus* Thomson (Hym., Ichneumonidae) and an unknown tachinid fly were obtained in the rearings. Collectively, the five species encountered caused 12% mortality to *P. orphisalis* based on the findings averaged over the 2-year study.

Predators of *P. orphisalis* included minute pirate bugs, *Orius* sp. (Hemiptera: Anthocoridae), feeding on the eggs, and big-eyed bugs, *Geocoris* sp. (Hemiptera: Lygaeidae), reduviid hemipterans and thomisid spiders feeding on the larvae.

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The First Record of the Delphacid *Liburniella ornata* in California (Homoptera: Fulgoroidea)

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Liburniella ornata (Stål) has been reported from Maine south to Florida and west to Texas, Nebraska, and Minnesota (Metcalf, 1943) as well as Bermuda (Van Duzee, 1909) and possibly Ecuador (see Muir, 1926). The only record of its occurrence west of the Rocky Mountains is that of Downes (1927) for British Columbia.

L. ornata is common and widely distributed in the eastern United States (Osborn, 1938) and is often collected in grassy meadows (Wilson, pers. obs.). It has been recorded feeding on black walnut (*Juglans nigra* L.) (Nixon and McPherson, 1977), and has been collected in June and from September to mid-October in Illinois (Weber and Wilson, 1981). Otherwise, no information is available on its biology. An adult was illustrated by Metcalf (1923) and the male genitalia were figured by Muir (1926).

We recently found three specimens of *L. ornata* from California among unidentified delphacids in the B. P. Bliven collection which has been acquired by the California Academy of Sciences and the California Department of Food and Agriculture.

The label information for the specimens is as follows:

CALIFORNIA: Humboldt Co., Fieldbrook, 23 July 1939, coll. B. P. Bliven, 1 male, 1 female; Pepperwood, Greenlaw Creek, 9 September 1973, coll. B. P. Bliven, 1 female [brachypter].

Although *L. ornata* is of widespread occurrence in the eastern U.S., it has only been collected in two localities in northern California. These limited collection records and the substantial geographic and ecological barriers suggest that this delphacid is an introduced species. Since females have a saw-like ovipositor and probably insert their eggs in plant tissues as do other delphacids, imported plant materials containing eggs, such as nursery or house plants or packing straw, may be a source of introduction. Its spread may be limited by the distribution of particular introduced plants or by a restricted set of ecological conditions present in the area where the specimens were collected.

ACKNOWLEDGMENT

We wish to thank Dr. P. H. Arnaud, Jr., Department of Entomology, California Academy of Sciences, San Francisco, for the loan of specimens.

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A New Species of *Orchesella* from Manitoba, Canada (Collembola: Entomobryidae)

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Several months ago I received six microscope slides containing seven specimens of *Orchesella* collected at Fort Whyte, Manitoba, Canada. The specimens were escorted by a letter from Dr. Kenneth Christiansen, Department of Biology, Grinnell College, Iowa, who stated that they were unlike any member of the genus from North America. A detailed study indicated that the specimens belong to the new species described below. The holotype and two paratypes are deposited in the Museum of Comparative Zoology, Cambridge, Massachusetts; two paratypes are in Dr. Christiansen's collection, and the remaining two paratypes are in my collection.

The system of nomenclature used for head macrochaetotaxy was described by Mari Mutt (1979). The system for the macrochaetotaxy of the second and third abdominal segments follows the terminology proposed by Christiansen and Tucker (1977; see also Christiansen and Bellinger, 1980) for the third segment, and which I have modified only slightly to use it also for the second abdominal segment (Mari Mutt, 1984).

***Orchesella manitobae* Mari Mutt, NEW SPECIES**
(Figs. 1–6)

Length to 1.8 mm ($\bar{x} = 1.56$ mm, $n = 7$). Antennae 3.9–4.4× length of head and 0.74–0.82× length of head plus body. Antennal segments 1 to 4 (Ant. 1–4) with violet pigment restricted mainly to sides and apices, segments 5 and 6 evenly pigmented. Head with median V-shaped band and sometimes a rounded patch anterior to this band. Pigment also laterally behind eye patches, around antennal bases, and on an intense spot between the bases of the antennae. Body evenly covered by light violet pigment (Fig. 1) except for a clear median streak on Th. 2 and Th. 3 (not visible in the photograph). Legs lightly but evenly pigmented or pigment restricted to coxae. Collophore pigmented distally, furcula without pigment.

Apex of Ant. 6 with a 3-pointed pin seta and without papilla or protruding structures. Anterior head macrochaetotaxy (Fig. 5) follows formula: An = 4–5, A = 7, M = 4, S = 10. Four macrochaetae along midline of head. Prelabral setae rarely bifurcated. Labral papillae (Fig. 6) with pointed tips. Differentiated seta of outer labial papilla well developed but not reaching apex of its papilla (Figs. 3, 4), latter with 2 anterior setae and a single posterior seta external to the differentiated seta. Setae of anterior labial row smooth and subequal in length. Posterior labial row internal to seta E with 4–7 setae per side, all ciliated. Setae E, L_1 and L_2 ciliated. Macrochaetal formula for second abdominal segment (Abd. 2): IA =

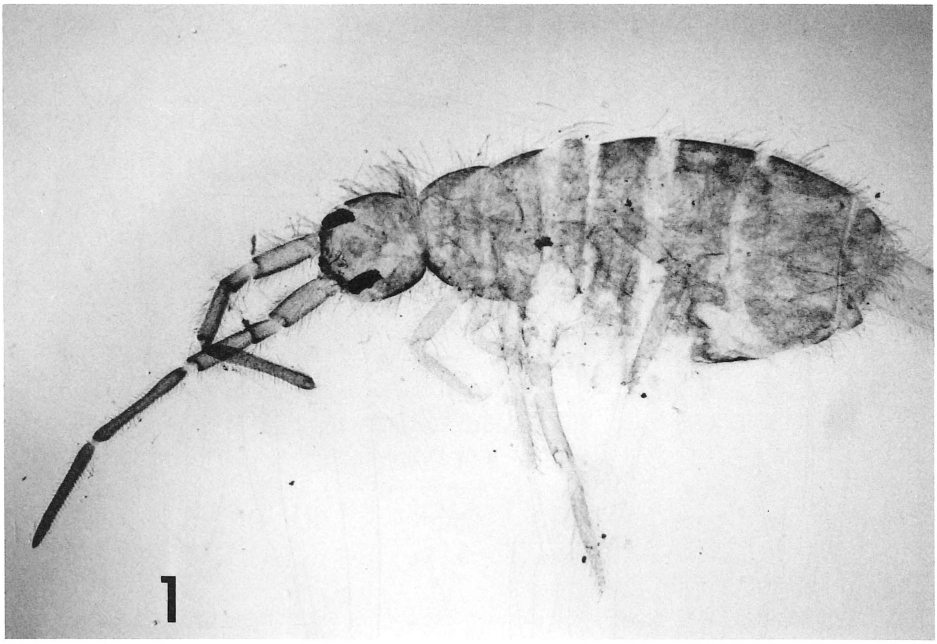


Figure 1. *O. manitobae.* Holotype, the specimen measures 1.8 mm.

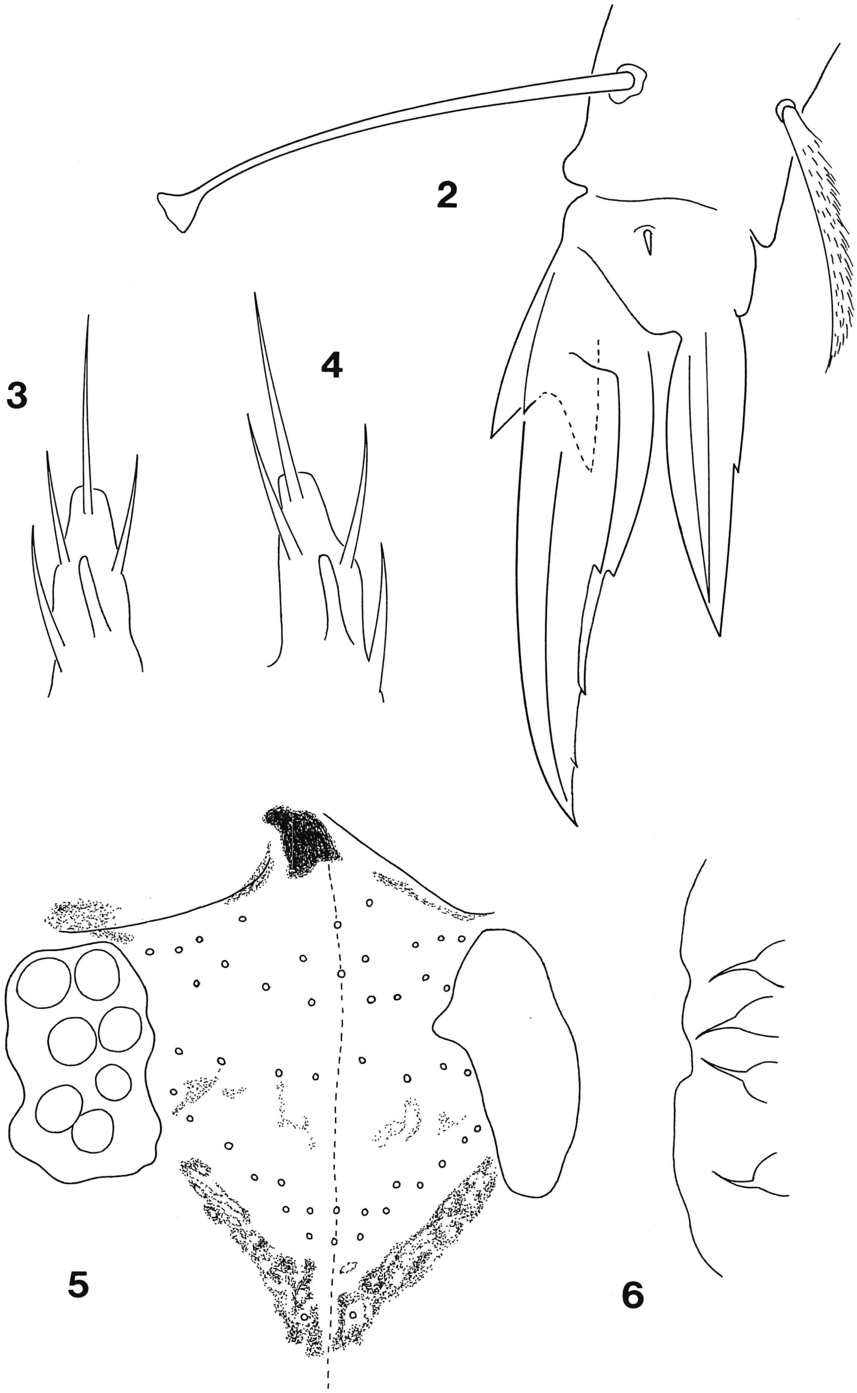
4–7, OA = 1–2, MP = 3 (4 on one side of one specimen), L = 2. Formula for Abd. 3: IA = 3–5, OA = 1, M = 2–4, L = 3. Corpus of tenaculum with 1 smooth seta. Inner margin of unguis with basal pair of teeth and 2 distal unpaired teeth (Fig. 2), outer margin with a small median tooth and 2 large lateral teeth. Unguiculus with a tooth placed near center of an outer lamella. Male genital plate circinate, with about 17 smooth setae arranged in 1 row around periphery of plate. Manubrium and dentes with many ciliated setae and no smooth setae. Mucro with 2 teeth and basal spine.

Diagnosis.—In coloration the new species comes closest to the North American *O. carneiceps* Packard and *O. folsomi* Maynard. The first is almost black except for the pale head (Christiansen and Bellinger, 1980:807) and the second is also dark but both head and mesothorax are yellow (Maynard, 1951:189). In *O. manitobae,* pigment is almost evenly distributed over head and body and is much lighter. The unguicular tooth of *O. manitobae* and *O. carneiceps* is placed near the middle of an outer lamella but in *O. folsomi* the tooth arises distally.

In Stach's 1960 revision of *Orchesella,* the new species keys out to *O. folsomi.* None of Stach's 117 figures illustrating the pigmentation of European species match closely the distribution of pigment of *O. manitobae.*

Comments.—The color pattern described above is based on the three largest specimens. Two small specimens possess very little pigment but it is still evenly distributed.

Head macrochaetotaxy was studied fully in only one specimen, in all others the head is distorted and it is impossible to work out the complete pattern. The macrochaetotaxy of Abd. 2 and Abd. 3 was studied in almost all the specimens



Figures 2–6. *O. manitobae.* 2. Prothoracic claws. 3. Right outer labial papilla with its differentiated seta and accompanying setae, note presence of one basal seta. 4. As preceding, left outer labial papilla. 5. Anterior head macrochaetotaxy. 6. Labral papillae.

and it revealed much variation, which limits the use of this character for separating closely related species. This variation may be due to changes in the number of setae during growth, inherent variability, and the asymmetric distribution of setae which is rather frequent in members of this genus.

Material examined.—All the specimens were collected by J. Aitchison on the surroundings of Fort Whyte, Manitoba, Canada. Below I give the accession number provided by Dr. Christiansen and additional data for each specimen.

Number 5507—holotype (♀), pitfall trap placed on small marshy meadow, 20.I.1982; 5508A—1 ♀, 25.VI.1980, 725 m; 5506—1 ♂, 1 ♀, 20.V.1981; 5511—1 ♀, 15.X.1980, an aspen-bur oak wood litter, 805 m; 5512—1 ♀, 20.VIII.1980, small marshy meadow being invaded by trees, 737 m; 5516—1 ♂, 20.VII.1979, in a meadow.

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Oviposition on the Backs of Female Giant Water Bugs, *Abedus indentatus*: The Consequence of a Shortage in Male Back Space? (Hemiptera: Belostomatidae)

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Females of the subfamily Belostomatinae (Lauck and Menke, 1961) characteristically fasten their eggs onto the dorsum of their mates, the males subsequently carrying the clutch until hatching. The use of males as oviposition sites led R. L. Smith (1979a) to suggest that at times a female's reproductive output may more likely be limited by the availability of unencumbered males on which to oviposit than by her own egg production. If this is true, then a gravid female unable to secure a "free" male may opt instead to lay a small clutch on some alternative substrate rather than not lay at all. Recently, Kruse and Leffler (1984) have observed egg-bearing females in a population of *Belostoma flumineum.* In this note I report a similar observation for *Abedus indentatus.*

Of 706 sexually-mature adult females[1,2] of *A. indentatus* Haldeman examined from 3 May to 15 August 1983 at Deep Canyon Creek, Palm Desert, California, I observed three females bearing eggs on their dorsum. (Females are identified by the possession of two tufts of setae located mesally near the apical margin of the genital plate [Menke, 1960].) The first female was collected on 17 May and carried 13 eggs (2.9 mm each), the second female was collected on 31 May and carried 2 eggs (2.6 mm each), and the third female was collected on 6 June and carried 52 eggs (3.6–4.6 mm each). The third female was recaptured on 7 July carrying 27 eggs, 14 of which had hatched as indicated by the presence of 14 empty chorions with ruptured cephalic caps (Smith, 1974). Whereas egg deposition on males begins at the apex of the hemelytra and proceeds forward, uniformly covering the dorsum of the male (Smith, 1974), the placement of eggs on the three females did not follow this pattern (see Fig. 1).

The fact that egg-encumbered females represent less than one percent of those examined in the field suggests that this phenomenon is quite rare. Since anatomical

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[1] All individuals were marked for future identification, some individually with numbers on their pronotum, others simply by making a small cut in one hemelytron. All three of the egg-bearing females collected in the field had been individually marked.

[2] The 706 females represent females seen for the first time. None of the 229 recaptured females that was examined carried eggs. An additional sample of 672 recently-eclosed, sexually-immature adult females was not included here since it was uncertain as to whether their exoskeletons had hardened enough to bear eggs. No recently-eclosed male or female was ever seen carrying a clutch.

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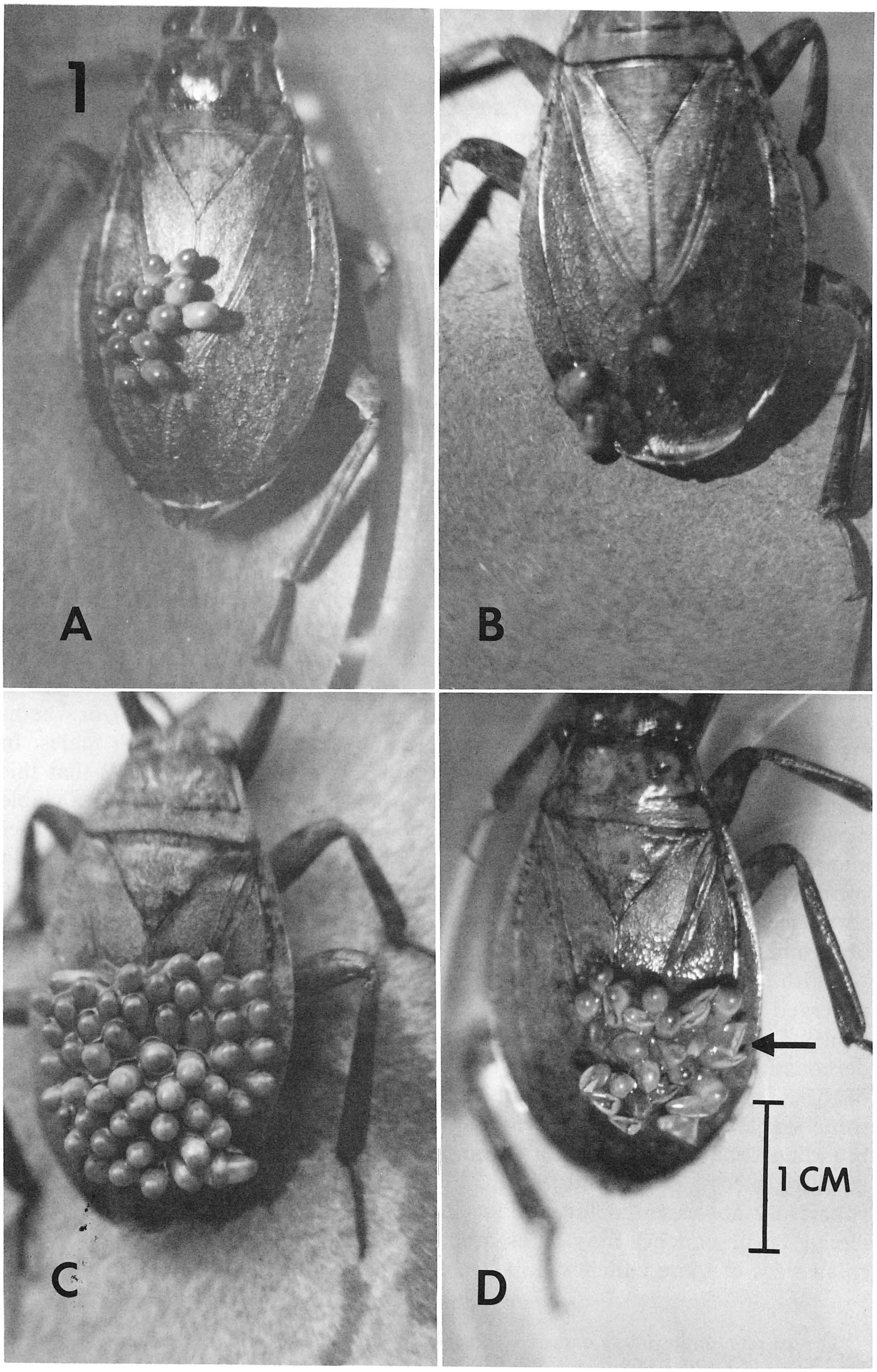
Figure 1. Photographs of three egg-carrying females (A, B, C) collected at Deep Canyon Creek, California. Photograph (D) depicts the female shown in (C) 31 days later. Note the presence of empty chorions (arrow).


1
A
B
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D
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constraints preclude a female from ovipositing on her own dorsum, the eggs must necessarily be the product of a second female. Smith (1979a) has reported that heavily gravid female *A. herberti* will lay small clutches of eggs on floating aquatic vegetation in their containers. He suggested that this apparent relaxation in specificity for an oviposition substrate was due to a prolonged absence of the appropriate surface, i.e., an unencumbered male. I have seen similar behavior in *A. indentatus,* and Menke (1960) has demonstrated that a gravid *A. indentatus* female will oviposit at least a few eggs on the back of a male of a different species if a conspecific is unavailable. In addition, I have observed two instances of egg carrying by females in the laboratory (clutch sizes of 9 and 3 eggs, respectively), both instances occurring in aquaria containing only females. Although neither of these encumbered females were successful at rearing the clutch (both clutches were discarded before the eggs could hatch), one of the eggs deposited on the female carrying three eggs expanded to 5.6 mm before it was lost. A well-developed embryo was found when the discarded egg was dissected.

Judging by their size, the eggs on the three *A. indentatus* females collected in the field were laid in May and June 1983, months in which the majority of sexually-mature *A. indentatus* males carried broods (86.44%, $n = 59$, and 74.55%, $n = 55$, respectively). In addition, the adult sex ratio during the same period appeared to be significantly skewed towards females.[3] (Interestingly, Kruse and Leffler [1984] indicate that a majority of *Belostoma flumineum* males were also encumbered when they made their observations.) I therefore suggest that egg-encumbered females are the consequence of at least a temporary shortage in available male back space. It remains unclear as to whether females are simply renewing their oviducal egg supply until "free" males become available (Smith, 1979a), or whether they are attempting to rear a small brood in the absence of such males. In regards to the latter hypothesis, I agree with Kruse and Leffler (1984) that this phenomenon is not an alternative to male brooding. However, it may be a viable option in instances where males are locally unavailable and when the only other alternative is not to lay at all. Finally, although egg-encumbered females could conceivably be the result of recognition errors made by ovipositing females, the complexity of courtship that characterizes *Abedus* (Smith, 1979a; Kraus, pers. obs.) makes this hypothesis unlikely.

Smith (1979b) has convincingly argued that the repeated bouts of copulation observed in *Abedus* are an adaptation to assure paternity through sperm presidence. The presence of hatched eggs on the back of the female recaptured in July demonstrates that the potential for cuckoldry does exist in nature, since the fertility of these eggs was dependent on the ovipositing female having retained at least some viable sperm from a previous mating. In addition, although male-specific brooding behaviors such as broodpumping appear to significantly increase the hatching success of a brood (Smith, 1976a, 1976b; Venkatesan, 1983), they are apparently not essential for egg development. In fact, the low survival rate of female-borne clutches may be as much a result of the irregular placement and small sizes of these clutches as it is a consequence of the disparity in brooding

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[3] The sex ratio of previously unmarked, sexually-mature adults closely fit a 2:1 ratio in favor of females ($n = 263$, x2 = 0.008, df = 1, $P > 0.9$). Sampling bias in catchability, analyzed over a 2-week period subsequent to marking, could not be detected ($n = 103$ recaptures, x2 = 0.60, df = 1, $P > 0.2$).

behaviors between the sexes. Even among males, small clutches appear to be much more susceptible to losing their adhesion and being discarded than large ones (especially when expansion of the developing eggs increases drag). In this regard, it is suggestive that the one field-collected female which was observed to have successfully reared a clutch also carried the largest number of eggs.

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The Larva of *Cyphomella gibbera* Saether (Diptera: Chironomidae)

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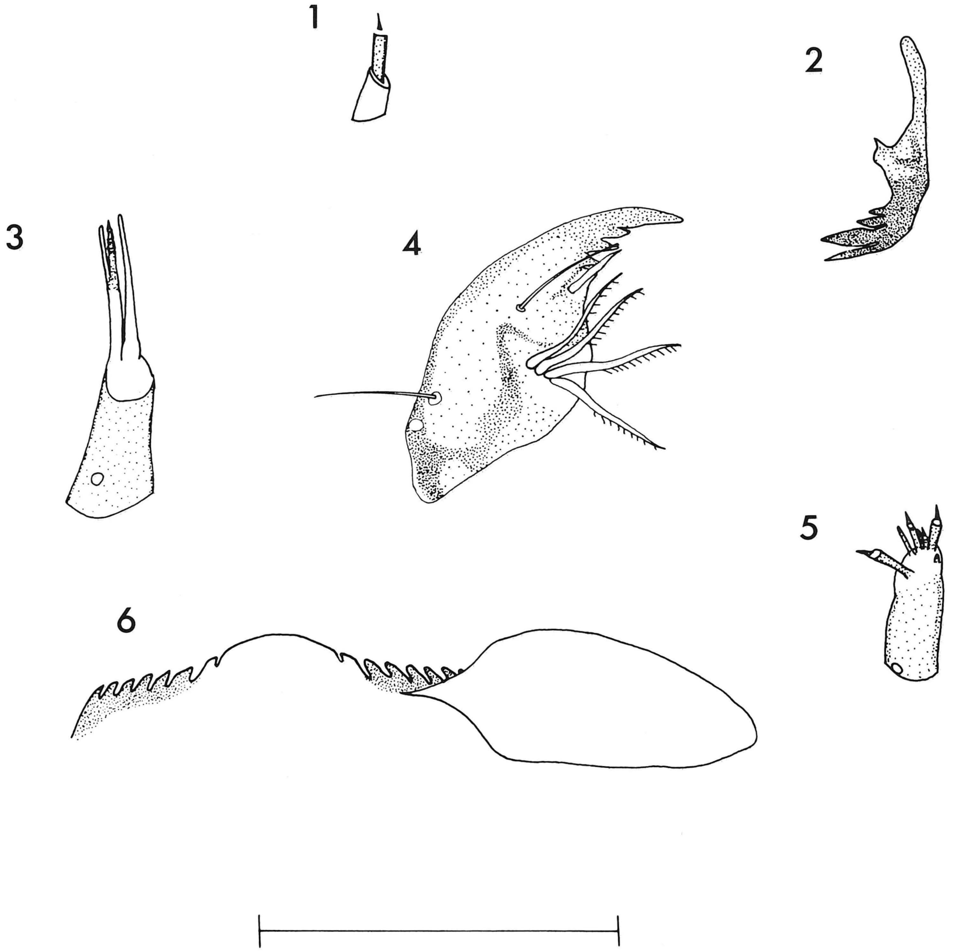
Abstract.—The larva of *Cyphomella gibbera* Saether is described. It differs from the other described *Cyphomella* sp. in having a smaller antennal ratio and in the colouration of the lateral notches of the median mental tooth.

Saether (1977) first described the male and pupa of *Cyphomella gibbera* based on material from South Dakota. In a recent study of Saskatchewan River Chironomidae (Mason, 1978) a number of imagines were reared from 4th instar larvae collected from sand, gravel, pebble and cobble substrates covered with silt or muck.

The larva of *C. gibbera* differs from that of *Cyphomella* sp. (Saether, 1977) in antennal and mental features. The former species has a smaller antennal ratio (AR of *C.* sp. is 1.78 and that of *C. gibbera* is 1.20–1.55) and the lateral notches of the median mental tooth are lighter-coloured than the lateral teeth. *Cymphomella* sp. has the lateral notches of the median mental tooth concolourous with the lateral teeth (Saether, 1977, Fig. 38H).

Cyphomella gibbera Saether, 1977, Bull. Fish. Res. Board Can., 196:103.

Head capsule brown, except tormae, U-shaped sclerite, lobes of premandibles, base of mandibles, lateral mental teeth and postoccipital margin which are dark brown. Head width 0.21–0.25, 0.23 mm. Ventral head length 0.09–0.10, 0.10 mm. Labral sensillum (Fig. 1) three-segmented. SI simple; length, 20–28, 23.8 μm. SII 45–60, 49.8 μm long. Pecten epipharyngis a small scale with 2–3 teeth. Premandibles (Fig. 2) length: 58–70, 63 μm. Antenna (Fig. 3) with apical three segments minute; total length 66–77, 71.3 μm; lengths of individual segments (μm) 35.0–45.0, 40.6; 16.0–28.0, 21.5; combined lengths of segments three to five, 5.0–10.0, 8.2; AR 1.2–1.6, 1.4; ring organ on basal 0.26–0.44, 0.33 of first segment; antennal blade length 26.0–37.0, 32.5 μm; antennal style on apex of segment two. Maxillary palp (Fig. 5) three-segmented, with 7–8 styles at apex of basal segment; ratio of length to basal width of first segment 1.5–2.0, 1.7. Mandible (Fig. 4) with three inner and apical tooth light-coloured; total length 90.0–112.5, 103.0 μm; ratio of length to basal width 0.6–1.2, 0.9; seta subdentalis narrowed apically, length 14.0–22.0, 17.8 μm; inner mandibular margin smooth. Mentum (Fig. 6) 94.5–130.5, 111.6 μm wide. Ventromental plates with smooth anterior margin and acute inner angle; striations distinct; ratio of width to length 2.3–2.9, 2.6. Posterior parapods with 15–16 simple hooks. Each procercus short, with eight anal setae. Anal tubules narrowed and rounded apically, 0.8–1.6 times as long as basal width.



Figures 1–6. *Cyphomella gibbera* Saether. 1. Labral sensillum. 2. Premandible. 3. Antenna. 4. Mandible. 5. Maxillary palp. 6. Mentum and premental plates (scale, 100 μm).

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The Nearctic Species of *Deuterixys* Mason (Hymenoptera: Braconidae)

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Abstract.—The three Nearctic species of the genus *Deuterixys* are described and keyed for the first time: *D. quercicola* Whitfield, *D. pacifica* Whitfield and *D. bennetti* Whitfield. Comparisons are made to the described Palearctic species.

The genus *Deuterixys* was proposed by Mason (1981) to include the members of Nixon's (1965, 1976) carbonarius-group of *Apanteles* Foerster: *A. carbonarius* (Wesm.), *A. rimulosus* Niez., *A. nixoni* Papp and *A. patro* Nixon, all Old World species. Below I describe and key three new species from North America, all reared from *Bucculatrix* spp. (Lepidoptera: Lyonetiidae).

MATERIALS AND METHODS

The 149 examined specimens came from the collections mentioned in the acknowledgments and from my own collection. All measurements were made to the nearest 0.1 mm at 50× or 100× using a Leitz dissecting microscope with an ocular micrometer. The wing figures were prepared from slide-mounted material using a microprojector. Morphological terminology follows that of Mason (1981).

Deuterixys Mason, 1981

A detailed generic description is provided by Mason (1981). The genus can be distinguished from other Microgastrinae by the following combination of features: vein r-m2 of fore wing (2r-m of Mason, 1981) absent; propodeum polished and bearing a strong longitudinal medial carina; tergite I of metasoma with mediobasal longitudinal groove; tergites II and III broad, subrectangular and usually densely sculptured; ovipositor sheaths short, decurved, subexserted. In addition, the species treated here share the following characteristics which may not be universal within the genus: metanotum sublaterally withdrawn from scutellum, exposing mesothoracic postphragma; sublateral setiferous lobes small but projecting anteriorly to near scutellum; tibiae of metathoracic legs with 10–12 spines on outer face; tergite II of metasoma with a more or less distinct raised medial section.

As far as is known, all *Deuterixys* species parasitize the larvae of *Bucculatrix* spp. and are unusual among Microgastrinae in emerging as adults from the host cocoon. In addition to the described Old World and the new Nearctic species discussed here, I have seen several undescribed species from Central and South America.

Deuterixys quercicola Whitfield, New Species
(Figs. 1, 4)

Holotype female.—Overall length 1.8 mm; fore wing length 1.9 mm.

Head: Antennae slightly longer than body, entirely dark; apical 9 flagellomeres with only one rank of placodes; 2nd flagellomere 3.0× longer than broad, 14th flagellomere 1.4× longer than broad. Frons 1.4× broader at midheight than midlength; inner margins of eyes converging towards clypeus. Punctation of head indistinct.

Mesosoma: Mesoscutum black, weakly punctate anteriorly, becoming nearly smooth and polished posteriorly. Scutellar disc mostly nearly impunctate with weak punctation appearing peripherally. Propodeum highly polished, virtually unsculptured except for strong medial longitudinal carina and weak transverse sculpturing near spiracles and along anterior third of medial carina; declivous over most of length.

Legs: Prothoracic legs fulvous except darker brown coxal bases, femoral bases and apical tarsomeres. Mesothoracic legs dark brown proximally except yellowish distal trochanters; femoral apices, tibiae and tarsi fulvous. Metathoracic legs dark brown except in vicinity of trochanters and bases of hind tibiae (here fulvous). Hind apical tibial spurs short, whitish, subequal in length.

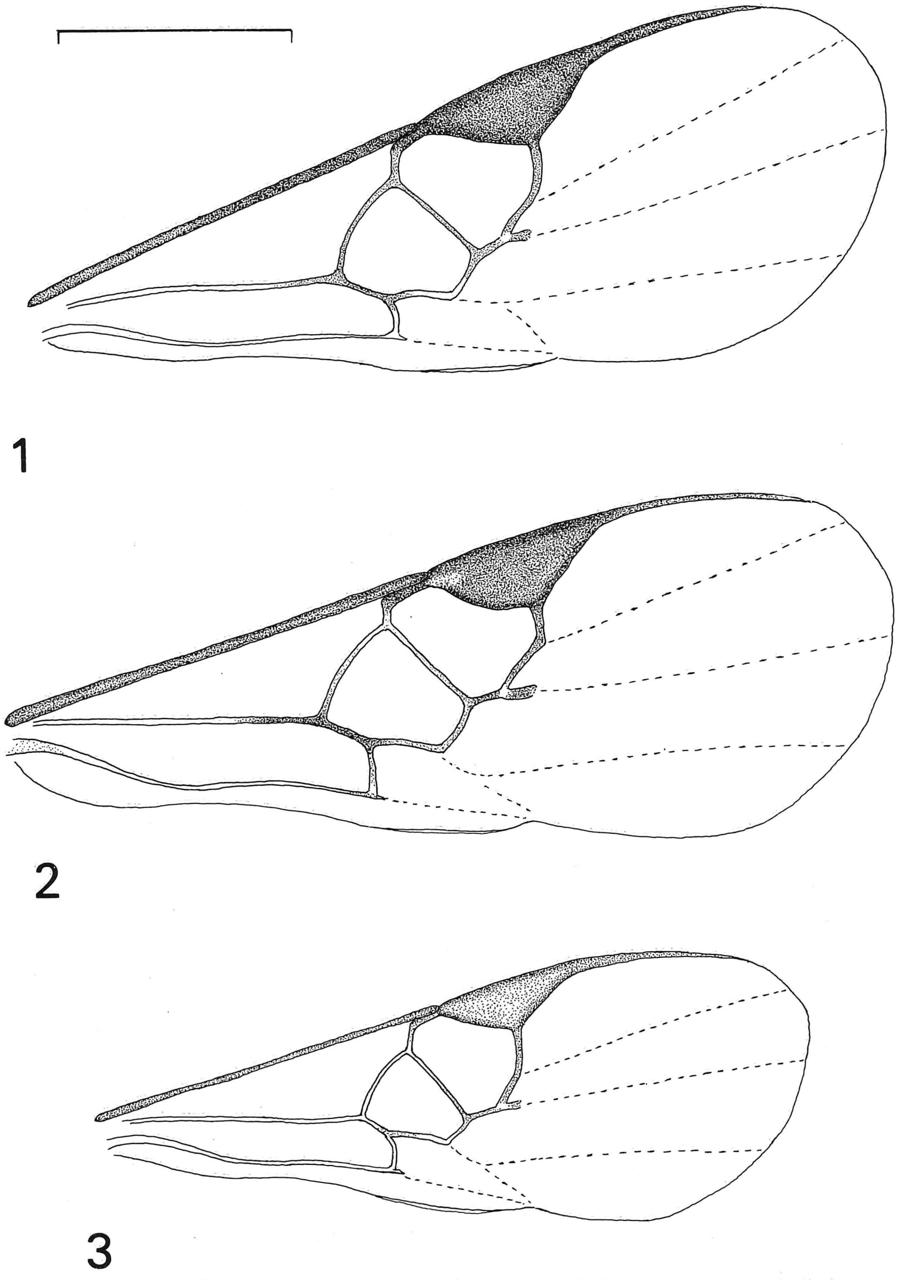
Wings: Tegulae dark brown, weakly translucent. Metacarp (R1) of fore wing virtually same length as stigma; 2r and 1Rs subequal in length and meeting at rounded, approximately 135 degree angle. Pigmentation of fore wing veins yellow-brown proximally, becoming more grey-brown distally.

Metasoma: Tergite I about 1.2× longer than posterior width, broadening slightly posteriorly, coarsely aciculorugose, with strong longitudinal groove surrounded by broad depression over basal 0.3. Tergite II quadrate, 1.6× broader than long, aciculorugose with stronger overlay of longitudinal sculpturing than in tergite I; medial raised portion indistinct. Tergite III separated from II by crenulate groove, becoming abruptly wider than tergite II but with rounded lateral margins; length somewhat less than that of tergite II; sculptured as in II. Tergite IV short, apically rounded, overlapped by III and with fine, weak longitudinal sculpturing over most of visible surface. Remainder of tergites telescoped under anterior 4 in dried specimens. Hypopygium short, blunt, with sparse long hairs. Ovipositor sheaths short, decurved, subexserted, apically hairy.

Male.—Similar to female except antennae longer, apical flagellomeres more slender (flagellomere 14 2.2× longer than broad), with only apical 4–5 flagellomeres having a single rank of placodes. Venation of fore wing slightly darker.

Variation.—Fore wing length 1.6–2.1 mm, with little or no sexual size dimorphism. Coloration comparatively uniform in California material (see Comments below for Eastern specimens).

Material examined.—Holotype ♀: CALIFORNIA: Alameda Co., Berkeley Hills, 7-VIII-1981 (J. B. Whitfield), reared ex *Bucculatrix albertiella* cocoons, JBW no. 81H4, emgd. 15–18-VIII-1981. Paratypes: CALIFORNIA: Alameda Co., Berkeley Hills, 1 ♂, 6 ♀, 2-V-1981 (J. B. Whitfield), same host as holotype, emgd. 9–18-V-1981, 1 ♂, 1 ♀, same data except coll. 25-IV-1982, emgd. 20–26-V-1982, 1 ♂, same data except coll. 11-IV-1981, emgd. 8-V-1981. Contra Costa Co., Tilden Regional Pk., 3 ♀, 8 ♂, 28-VIII-1982, emgd. 1–22-IX-1982 (J. B. Whitfield), reared



Figures 1–3. Fore wings of 1, *Deuterixys quercicola,* n. sp.; 2, *D. pacifica,* n. sp.; 3, *D. bennetti,* n. sp. Scale = 0.5 mm.

ex *Bucculatrix albertiella* on *Quercus agrifolia,* JBW no. 82H12. Holotype deposited in USNM; paratypes in USNM, CNC, UCB.

Other material: CALIFORNIA: Alameda Co., Strawberry Cyn., 1 ♂, 1 ♀, 11-IV-1968 (P. A. Opler), reared ex *Bucculatrix* on *Quercus agrifolia,* JAP no. 68D117-8, 7 ♂, 6 ♀, 6-IX–31-X-1975 (D. S. Green), same host. Contra Costa Co., 2 mi E Antioch, 1 ♂, 28-II-1968 (P. A. Opler), reared ex *Bucculatrix* on *Quercus agrifolia*; Briones Regional Pk., 1 ♂, 11-VIII-1981 (J. B. Whitfield). Los Angeles Co., 10 mi N Castiac, 1 ♂, 1 ♀, 26-IV-1977 (D. S. Green), reared ex *Bucculatrix* on *Quercus agrifolia*. Mendocino Co., Univ. Calif. Hopland Field Sta., 880′, 1 ♂, 5-V-1968, malaise trap (W. J. Turner). Orange Co., O'Neill Park, 1 ♀, 25-II-1977, reared ex *Aeaea dulcedo* on *Q. agrifolia* (D. S. Green). San Diego Co., 4 mi W Ramona, 1 ♂, 26-II-1977, reared ex *B. albertiella* on *Q. agrifolia* (D. S. Green). San Luis Obispo Co., 9 mi SW Atascadero, 1 ♂, 4-V-1976, reared ex *B. albertiella* on *Q. agrifolia* (D. S. Green). Santa Barbara Co., Santa Cruz Isl. nr. field sta., 1 ♀, 1-V-1976, reared ex *B. albertiella* on *Q. agrifolia* (D. S. Green). Sutter Co., Feather R. at Nicolaus, 1 ♂, 2-X-1982, reared ex *Bucculatrix* sp. on *Quercus lobata*, JBW no. 82K19 (J. B. Whitfield), 1 ♀, 4-X-1982, reared ex *Bucculatrix* sp. on *Artemisia douglasiana*, JAP no. 82K1 (D. L. Wagner). Tulare Co., 3 mi N Kaweah, 1 ♀, 28-IV-1979, reared ex *Bucculatrix* sp. (J. A. Powell).

Hosts.—Bucculatrix albertiella Bsk. on *Quercus agrifolia* Nee, *Bucculatrix* sp. on *Quercus lobata* Nee and possibly other *Bucculatrix* spp. on oaks. The record from *Aeaea dulcedo* is probably in error and could easily have resulted from unseen *Bucculatrix* contaminants in rearing material. I suspect the record from *Bucculatrix* sp. on *Artemisia douglasiana* Bess. is also mistaken; I know that the specimen from *Bucculatrix* from *Quercus lobata* was taken very nearby and *Bucculatrix* larvae could easily have spun down from the oaks onto the *Artemisia* foliage to pupate. All other *Deuterixys* from *Bucculatrix* on *Artemisia* have been *D. pacifica*, n. sp., described below.

Comments.—Several specimens in the USNM collection from Baltimore, Maryland, Washington, D.C. and Tallulah, Louisiana agree with the above description in all features except the metathoracic femora are entirely fulvous and veins 1Cu1 and 2Cu1 of the fore wing are less strongly pigmented than in the California material. The specimens tend to be slightly smaller as well, but I have seen only 4 eastern U.S. individuals. I provisionally include these as *D. quercicola*, but more material, including rearing records for the eastern forms, is necessary for a more certain determination. It is certainly possible that *D. quercicola* appears widely throughout the range of oak-feeding *Bucculatrix*.

This species can be distinguished from *D. carbonaria* (Wesm.) and *D. nixoni* (Papp), its most similar Palearctic relatives, by its possession of the following combination of features: 1) posteriorly broadening metasomal tergite I; 2) metasomal tergite IV with fine longitudinal sculpturing over most of its surface; 3) tergite IV usually concealing successive terga in dorsal view; 4) propodeum with strong medial longitudinal carina and 5) hind coxae dark brown. The resemblance to *D. nixoni* is striking; it is possible the two may eventually prove to be synonymous.

Deuterixys pacifica Whitfield, New Species

(Figs. 2, 5)

Holotype female.—Overall length 1.6 mm, fore wing length 1.7 mm.

Head: Antennae approximately same length as body, nearly black throughout, apical 9 flagellomeres with only one rank of placodes; 2nd flagellomere 3.0× longer than wide; flagellomere 14 1.3× longer than wide. Frons 1.4× broader at midheight than long down middle; inner margins of eyes weakly converging towards clypeus. Punctation of frons, vertex and postgenae indistinct; microsculpture producing dull metallic reflections in diffused light.

Mesosoma: Mesoscutum shallowly punctate anteriorly, becoming less distinctly and more sparsely punctate posteriorly. Scutellar disc distinctly punctate, duller between punctures than mesoscutum, strongly convex posteriorly. Propodeum highly polished, virtually unsculptured except for strong medial longitudinal carina; weakly convex in profile.

Legs: Prothoracic legs basally dark brown to black up to distal 0.5 of femur, lighter fulvous beyond this point. Mesothoracic legs dark brown to black except distal 0.2 of femur and proximal 0.6 of tibia, which are fulvous. Metathoracic legs very dark brown to black except yellowish proximal 0.6 of tibia. Apical spurs of hind tibiae short, whitish, subequal in length.

Wings: Tegulae dark brown, weakly translucent. Metacarp (R1) of fore wing slightly shorter than stigma. 2r and 1Rs virtually straight, subequal in length, meeting at about 130 degree angle. Venation including stigma mainly deep brown; M+Cu and 1A+2A weakly pigmented proximally.

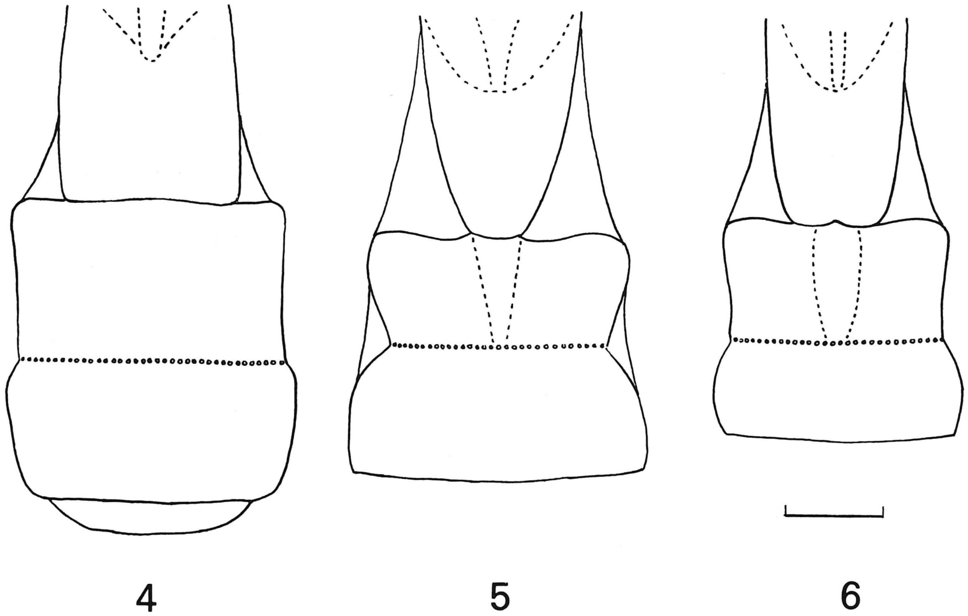
Metasoma: Tergite I strongly narrowing posteriorly, approximately 2.5 × broader anteriorly than posteriorly, with strong medial longitudinal groove over basal 0.4–0.5; longitudinally rugose/carinulate over posterior 0.7. Tergite II 2.3 × broader anteriorly than long down middle, lateral margins converging noticeably posteriorly; surface longitudinally aciculorugose. Tergite III separated from II by weak crenulate furrow, abruptly widening, becoming broader posteriorly than tergite II at broadest point; surface with fine longitudinal sculpturing mediobasally, otherwise very weakly if at all sculptured. Laterotergites dark yellow-brown. Succeeding terga of usual unsculptured, overlapping type. Hypopygium short, blunt apically, somewhat truncate at tip, with sparse long hairs. Ovipositor sheaths short, subexserted, decurved, polished, with hairs concentrated apically.

Male.—Similar to female except antennae clearly longer than body, with all but apical 4–5 flagellomeres with 2 ranks of placodes. Length/width ratio of flagellomere 14 = 2.3 (other apical flagellomeres also more elongate than in female).

Variation.—Fore wing length 1.6–2.0 mm. No apparent sexual size dimorphism. Coloration comparatively uniform except some darker high elevation individuals, which also tend to have smoother metasomal sculpturing. A few specimens have the first metasomal tergite less strongly narrowed than in the type series.

Material examined.—Holotype ♀: CALIFORNIA: Contra Costa Co., Tilden Regional Pk., 15-VIII-1982 (J. B. Whitfield). Paratypes: CALIFORNIA: Contra Costa Co., Tilden Regional Pk., 6 ♀, 13 ♂, 15-VIII-1982 (J. B. Whitfield), 8 ♀, 6 ♂, 29-VIII-1982 (JBW), 8 ♀, 2 ♂, 25-IV-1983 (JBW); Chabot Regional Pk., 3 mi N Lake Chabot, 1 ♂, 12-VII-1980 (JBW); nr. Clayton, 1 ♀, 27-II-1982, reared ex *Bucculatrix,* JAP no. 82B29, emgd. 21-III-1982 (D. L. Wagner). Alameda Co., Berkeley, 11 ♀, 6 ♂, 10-IV-1983, reared ex *Bucculatrix* on *Baccharis pilularis,* JBW no. 83D19 (J. B. Whitfield). Holotype deposited in USNM; paratypes in USNM, CNC, UCB.

Other material: CALIFORNIA: Alameda Co., Berkeley Hills, 2 ♂, 6/7-VIII-1982 (J. B. Whitfield); Patterson Reserve, Del Valle Lake, 1 ♂, 29-IV-1974, reared ex microlepidoptera, JAP no. 74D40-41 (J. A. Powell). Contra Costa Co., Pt. Molate, Richmond, 1 ♂, XI-1969, reared ex *Iva axillaris,* JAP no. 69L9. El Dorado Co., Fallen Leaf Lake, 1 ♀, 9-VII-1983, reared ex *Bucculatrix* on *Artemisia tri-*



Figures 4–6. Basal tergites of 4, *Deuterixys quercicola,* n. sp.; 5, *D. pacifica,* n. sp.; 6, *D. bennetti,* n. sp. Scale = 0.1 mm.

dentata, JBW no. 83G67 (J. B. Whitfield). Riverside Co., Thousand Palms, 1 ♂, 27-IV-1955 (W. R. Richards); Palm Springs, 1 ♀, 3-V-1955 (W. R. M. Mason). San Luis Obispo Co., Oso Flaco Lake, 2 ♀, 13-VII-1959 (C. A. Campbell). San Mateo Co., San Bruno Mts., 1 ♂, 12-III-1982 (J. B. Whitfield), 2 ♀, 21-IV-1983, reared ex *Bucculatrix* on *Baccharis pilularis,* JADeB. no. 83111-E (J. A. DeBenedictis), 1 ♀, 15-VI-1982, reared ex *Bucculatrix* on *Baccharis pilularis* (D. L. Wagner). Ventura Co., San Nicolas Isl., 1 mi SSE 1000 Springs, 1 ♀, 6–8-VI-1980 (S. E. Miller, P. M. Mercer). NEW MEXICO: Springer, 1 ♂ (no date) (C. N. Ainslee). UTAH: Guardsman Pass, nr. Brighton, 1 ♂, 10-VII-1981, 9800′ (B. H. Poole). BRITISH COLUMBIA: Robson, 1 ♀, 13-V-1947 (H. R. Foxlee).

Hosts.—Bucculatrix variabilis Braun and *Bucculatrix separabilis* Braun on *Baccharis pilularis* DC, *Bucculatrix* sp. on *Artemisia douglasiana* Bess., *Bucculatrix* sp. on *Artemisia tridentata* Nutt. and *Bucculatrix* sp. on *Iva axillaris* Pursh. I suspect a wide range of *Bucculatrix* spp. on Compositae serve as hosts.

Comments.—No other known species of *Deuterixys* has the first metasomal tergite so strongly narrowed apically. The relative lack of sculpturing on the third tergite is also distinctive among the Nearctic species, although this feature is shared with the Palearctic *D. rimulosa* (Niez.). The species appears to be widespread in Western North America, probably in part due to the broad range of *Artemisia tridentata.*

Deuterixys bennetti **Whitfield, New Species**
(Figs. 3, 6)

Holotype female.—Overall length 1.6 mm, fore wing length 1.7 mm.

Head: Antennae approximately 1.1–1.2× longer than body; scapes and pedicels light yellow-brown, more distal portions of antennae dark brown; apical 9 flagellomeres with only one row of placodes; 2nd flagellomere 3.8× longer than broad; 14th flagellomere 1.2× longer than broad. Frons 1.3× broader at midheight than long down middle; inner margins of eyes weakly converging towards clypeus. Punctation of frons, vertex and postgenae faint; microsculpture producing dull metallic reflections in diffused light.

Mesosoma: Mesoscutum shallowly punctate anteriorly, becoming nearly impunctate posteriorly. Scutellar disc sparsely, shallowly punctate throughout, evenly convex. Propodeum highly polished, virtually without sculpturing except for strong medial longitudinal carina and weak transverse ridging in immediate vicinity of longitudinal carina and lateral margins; propodeum strongly convex anteriorly in profile.

Legs: Prothoracic legs fulvous virtually throughout except slightly darker apical tarsomeres. Mesothoracic legs fulvous virtually throughout except infuscate distal half of tibiae and apical tarsomeres. Metathoracic legs with darkened coxal bases, apical third of femora, apical two-thirds of tibiae and entire tarsi; remainder of hind legs lighter yellow-brown. Hind tibial spurs whitish, subequal in length, 0.4× as long as hind basitarsi.

Wings: Tegulae pale yellowish. Metacarp (R1) 1.2–1.3× length of stigma; 2r and 1Rs subequal, 2r very faintly arched, the two veins meeting at a 145 degree angle. Venation of fore wing, including stigma, translucent pale yellow-brown.

Metasoma: Tergite I weakly narrowing posteriorly, 2× longer than broad at midlength, with strong medial longitudinal groove over anterior 0.4; coarsely aciculorugose over most of surface. Tergite II strongly quadrate, slightly broader anteriorly than posteriorly, 1.8× broader anteriorly than long down middle; surface coarsely aciculorugose throughout. Tergite III separated from II by strong crenulate furrow, wider than II, abruptly widening over anterior 0.4, then parallel-sided; 2.2× broader posteriorly than long down middle; surface coarsely, longitudinally carinulate over most of surface. Succeeding terga virtually sculptureless, normally overlapping. Laterotergites translucent orange-brown. Hypopygium short, blunt but not truncated apically, sparsely clothed with long hairs. Ovipositor sheaths short, subexserted, decurved, polished, with hairs concentrated apically.

Male.—Similar to female except antennae longer, more slender (14th flagellomere 2.2× longer than broad), with single placode bands only on apical 4; antennae generally somewhat lighter brown. Hind legs mostly evenly darker fulvous than in female with nearly black coxae and lighter proximal portions of tibiae.

Variation.—Fore wing length 1.7–1.9 mm. No apparent sexual size dimorphism. Coloration rather uniform in limited series available; some specimens in poor condition and somewhat bleached. Some variation exists in the number of spines on the outer faces of the hind tibiae.

Material examined.—Holotype ♀: FLORIDA: Nassau Co., O'Neil, V-1960, reared from *Bucculatrix* on *Baccharis halimifolia* (F. D. Bennett). Paratypes: FLORIDA: Nassau Co., 2 ♀, 3 ♂, V-1960, same host (F. D. Bennett); Brevard Co., Melbourne Beach, 2 ♀, 1 ♂, V-1960, same host (F. D. Bennett); Walkulla Co., Medart, 1 ♀, V-1960, same host (F. D. Bennett); St. Johns Co., St. Augustine, 1 ♀, V-1960, same host (F. D. Bennett); Pinellas Co., St. Petersburg, 1 ♀, V-1960, same host (F. D. Bennett), 3 ♀, X-1960, same host (F. D. Bennett); Pasco Co., Elfers, 1 ♂, 16-IV-1960 (O. Peck). Holotype deposited in USNM, paratypes in USNM, CNC collections.

Hosts.—The only recorded host is *Bucculatrix* sp. on *Baccharis halimifolia* L. It is likely that other *Bucculatrix* spp. feeding on shrubby composites in the Southeast may also serve as hosts.

Comments.—The species is named after F. D. Bennett, the collector of most of the type series. *D. bennetti* strongly resembles the Palearctic *D. rimulosa* (Niez.) (=*D. comes* (Wilk.) according to Papp, 1971), but differs in the much longer metacarp and the more strongly sculptured third metasomal tergite.

KEY TO NEARCTIC SPECIES OF *DEUTERIXYS* MASON

1\. First tergite of metasoma narrowed posteriorly 2
First tergite broadened posteriorly .... *D. quercicola,* n. sp.
2\. Tegulae pale yellow-brown; third metasomal tergite distinctly sculptured over most of its surface .... *D. bennetti,* n. sp.
Tegulae dark brown; third tergite at most only weakly sculptured anteromedially .... *D. pacifica,* n. sp.

ACKNOWLEDGMENTS

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David L. Wagner was of great assistance in rearing the parasitoids from field-collected host material, and in determining the hosts. I also appreciate the comments of H. V. Daly and W. R. M. Mason, who reviewed the manuscript.

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Cutworm Defoliators of Ryegrass[1]

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Abstract.—Cutworm species that constitute a common complex that defoliate ryegrasses in Oregon are: *Dargida procincta* (Grote), *Pseudaletia unipuncta* (Haworth), *Leucania pallens luteopallens* Grote, *Diarsia pseudorosaria* (Hardwick), *Peridroma saucia* (Hubner), and *Leucania insueta* Guenée. In this study *D. procincta* and *P. unipuncta* rapidly defoliated ryegrass by severing leaves and wasted more foliage than they ate. *D. pseudorosaria* and *L. p. luteopallens* slowly defoliated ryegrass and seldom wasted foliage by severing leaves. Black-light trap captures provided reasonably good estimates of adult flight of all species except *D. procincta.*

Various foliar feeding cutworms infest ryegrasses in the Pacific Northwest, but little is known about the importance or type of damage inflicted by many species. Among the cutworms common in ryegrass in the Willamette Valley of Oregon, *Pseudaletia unipuncta* (Haworth) and *Peridroma saucia* (Hübner) are well known pests (Bohart, 1948; Rice et al., 1982). Lesser known but common grass feeders include *Diarsia pseudorosaria* (Hardwick), *Leucania pallens luteopallens* Grote, *Leucania insueta* Guenée, and *Dargida procincta* (Grote) (Crumb, 1956). Of these species, Thompson (1943) considered *D. procincta* to be the most important pest.

The impact of ryegrass defoliators may become more important in seed production with the recent introduction of plant growth retardants that, in effect, decrease production of foliage and increase seed yields (Chilcote, 1983). This study was conducted to determine the dominant species and relative abundance of foliar feeding cutworms in seed fields of ryegrass. Also, greenhouse feeding tests were made to determine the type of feeding injury inflicted by individual species.

MATERIALS AND METHODS

Seasonal flight of adults was monitored with battery-powered black-light traps placed in seed fields of ryegrass near Corvallis, Oregon. Traps were operated 3–4 nights weekly during the flight season. Then, mean daily trap captures were computed and multiplied times 7 so weekly data were comparable. Larval populations were estimated by collection of larvae from harvested seed on a field basis. When fields were windrowed for harvest, larvae sought shelter in, and often pupated within, the windrow. A large number of these larvae were carried along with seed into the combine. As harvested seed was unloaded, larvae curled up

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[1] Contribution of the Agricultural Research Service, USDA, in cooperation with the Agricultural Experiment Station, Oregon State University, Technical Paper No. 7073 of the latter.

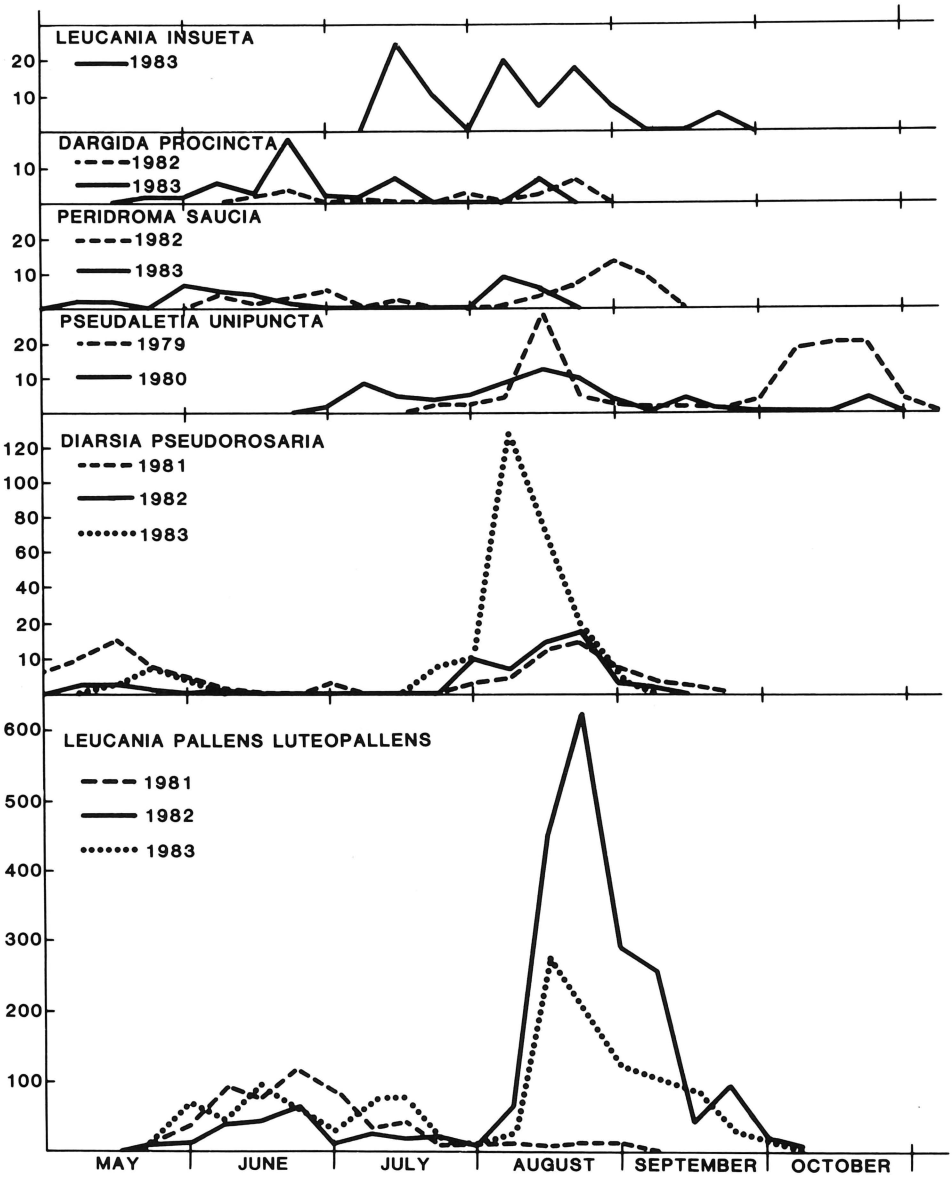

Figure 1. Captures of cutworm adults in commercial fields of ryegrass with black-light traps.

and rolled down the pile of seed. These larvae were collected until at least 100 specimens were obtained from each field. The larvae were taken to the laboratory to determine the percentage of each species in a given field.

Feeding tests were conducted in the greenhouse with densely seeded ryegrass grown in pots (15 cm wide) to a height of 30–40 cm. Larvae from the previously described collections were temporarily confined overnight in large freezer containers and fed leaves of ryegrass. The next day, 20 active and uninjured larvae (predominantly 4th–5th instars) were caged on individual pots of ryegrass. This

Table 1. Larval species composition of foliar feeding cutworms (%) obtained from several types of ryegrass during harvest, Corvallis, Oregon.

	Tetraploid		Annual				Perennial			
Cutworm	I[a]	II	III	IV	V	VI	VII	VIII	IX	$\bar{x}$
Dargida procincta	81	85	27	89	16	88	81	67	96	70
Leucania pallens luteopallens	6	3	26	2	54	1	7	10	1	12
Pseudaletia unipuncta	5	1	24	3	13	2	8	21	1	9
Diarsia pseudorosaria	5	8	12	3	16	3	1	2	0	6
Periodroma saucia	3	3	11	3	1	6	3	0	2	3

[a] Fields I, III, V, VI, VIII sampled in 1980; all others sampled in 1981.

procedure was replicated 4 times for each species of cutworm. Infested plants were observed daily for the type and degree of feeding damage inflicted by the larvae until the plants were defoliated.

RESULTS AND DISCUSSION

Adult flight.—The species of moths captured in light traps in ryegrass were, in decreasing order of abundance: *L. p. luteopallens, D. pseudorosaria, P. unipuncta, L. insueta, P. saucia* and *D. procincta* (Fig. 1). The abundance of species was variable from year to year, especially the second generation of moths. For example, the August generation of *L. p. luteopallens* was barely detectable in 1981, but very strong in 1982. A strong second generation seems to occur only when rainfall is adequate to stimulate grass regrowth soon after harvest.

Larval populations.—The species found in larval samples in decreasing order of abundance were: *D. procincta, L. p. luteopallens, P. unipuncta, D. pseudorosaria* and *P. saucia*. *D. procinta* was by far the most abundant larval species (Table 1) and the least abundant in light traps. Often both larvae and pupae of this species were easily found in windrows when relatively few or no adults were captured in light traps. Apparently, the species is only weakly attracted to light traps. Based on larval samples, 5 species clearly constitute a common cutworm complex in all types of ryegrass. Three species were present in all fields, and the remaining two species were found in 8 of 9 fields (Table 1). The relative abundance of larvae of a given species varied among fields during the same year. For example, *L. p. luteopallens* constituted only 1% of the population in one field and 54% in another. Both fields were the same variety, and no insecticide was used on either field.

Feeding tests.—Larvae of 4 cutworm species were caged on ryegrass in the greenhouse to evaluate feeding behavior in relation to plant defoliation. Larvae of *D. procincta* and *P. unipuncta* initiated feeding on the margin of leaves near the base of the plant. After larvae had eaten halfway through the leaf for several cm, they often completely severed the leaf and then climbed on to a new leaf and repeated this behavior. The amount of leaf foliage wasted (not eaten) was substantially greater than the amount actually consumed by larvae of both species. The plants (30–40 cm in height) in all pots were completely defoliated by 20 larvae after 2 days, leaving developing seed culms severed 3–5 cm above the soil. The feeding behavior of both species was very similar.

In contrast, larvae of *L. p. luteopallens* fed along the leaf margins and often consumed the tissue on only one side of the leaf midrib. As feeding progressed toward the top of the leaf, the midrib was severed but some tissue remained so the leaf was partially attached. A few leaves were eventually severed but only after substantial amounts of foliage were consumed. Complete defoliation by 20 larvae required 8 days or 4 times as long as *D. procincta* or *P. unipuncta.*

Larvae of *L. pseudorosaria* also fed along the leaf margins and consumed nearly all the tissue on one side of the midrib of the leaf. Larvae rarely penetrated the midrib or wasted foliage by severing the leaf. These larvae consumed foliage rather slowly and none of the plants was completely defoliated by 20 larvae after 10 days. In fact, plant growth compensated for some defoliation during the test.

Light traps clearly were inadequate to assess adult populations of all species in the complex of infested ryegrasses. The relative abundance of species varied among fields and years, but the order of species dominance in light traps was about the same as in larval samples except for *D. procincta,* the most important defoliator of ryegrasses. Sampling larval populations will require visual inspection of lodged foliage, windrows, or harvested seed because sweeping with an insect net was not effective. Two considerations are important in assessing potential damage: 1) the propensity of the dominant species to sever developing culms and 2) relative abundance. Tests herein have shown that *D. procincta* and *P. unipuncta* were capable of severing leaves and culms, whereas *P. pseudorosaria* and *L. p. luteopallens* may contribute to defoliation but plant damage was less severe.

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Descriptions of the Immature Stages of *Delphacodes bellicosa* (Homoptera: Fulgoroidea: Delphacidae)

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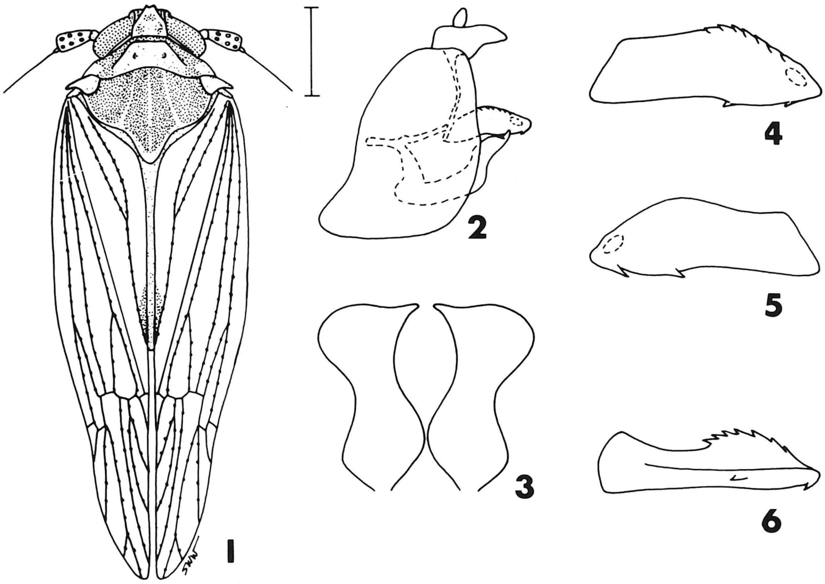
Abstract.—The immature stages of *Delphacodes bellicosa* Muir and Giffard are described and illustrated. Features useful in separating nymphal instars include the number of metatarsal segments, the size, shape, and dentation of the metatibial spur, the increase in body size, wingpad size, and number of pits. Eggs of *D. bellicosa* were found inserted in stems and nymphs and adults were observed feeding on leaves of knotgrass (*Paspalum distichum* L.)

Delphacodes bellicosa Muir and Giffard (1924) is known only from the male holotype collected at Three Rivers, Tulare Co., California. On 17 May 1981 I collected 3 males of this species at a manmade lake in Bidwell Park, Chico, Butte Co., California. Identity of females collected is questionable because two other *Delphacodes, D. consimilis* (Van Duzee) and *D. foveata* (Van Duzee) were also collected at the lake.

On 20 May 1981 an adult male *D. bellicosa* was observed feeding on the leaves of knotgrass (*Paspalum distichum* L.). Ten plants were returned to the laboratory and 52 eggs were found inserted in one stem; 10 of these were preserved in 95% ethyl alcohol and the remaining eggs removed from the surrounding plant tissue with a fine needle and placed on a strip of filter paper. The strip was placed in a petri dish that was covered on the bottom with a disc of moistened filter paper. The dish was covered with plastic secured with an elastic band and covered with the lid; the plastic prevented newly hatched nymphs from escaping between the dish and lid. Upon hatching, the nymphs were provided with a cutting of knotgrass leaf added to the dish and replaced every three to four days. The dish was kept in an incubator under a 16L:8D photoperiod at 29 ± 1.4°C. All of the eggs hatched. Because 12 of the 1st instars died within a few days of hatching (apparently by drowning in the condensation on the walls and plastic cover of the dish), the remaining nymphs were transferred to knotgrass that had been planted in a clay pot; this knotgrass was collected at the same locality and carefully examined for eggs before transplanting. The pot was covered with a glass cylinder and covered with a piece of fine mesh gauze secured with an elastic band. The potted knotgrass was kept in a greenhouse.

In order to obtain specimens for description several nymphs were collected from the potted plant each week until the emergence of 3 adult males. Specimens to be described were preserved in 95% ethyl alcohol. The first instar is described in detail but only major changes from previous instars are described for subsequent instars. Comparative statements refer to previous instars (e.g., more elongated).



Figures 1–6. *Delphacodes bellicosa* Muir and Giffard. 1. Habitus of male macropter, vertical bar = 0.5 mm. Male genitalia. 2. Complete left lateral view. 3. Styles in caudal view. 4. Aedeagus in left lateral view. 5. Aedeagus in right lateral view. 6. Aedeagus in ventral view.

Dimensions of eggs and nymphs are expressed in millimeters as mean ± SE. For nymphs, length was measured from tip of vertex to tip of abdomen; width was measured across the widest part of the body. Thoracic length was measured along the midline from the anterior margin of the pronotum to the posterior margin of the metanotum.

Adult (Figs. 1–6).—Muir and Giffard (1924) described an adult male brachypter and provided illustrations of the aedeagus. An adult male macropter is illustrated in Figure 1 and male genitalia in Figures 2–6. Collecting data for all specimens are: CALIFORNIA: Butte Co., Chico, 17 May 1981 (3 ♂), 20 May 1981 (11 ♂; plus 3 ♂ "collected as eggs, greenhouse reared"), 27 May 1981 (4 ♂), 1 June 1981 (1 ♂).

Egg (Fig. 7).—Length 0.76 ± 0.007; width 0.19 ± 0.003; 10 specimens examined. Eggs laid singly; each elongated, curved, subconical, narrowing at ends, anterior end blunt, posterior end broadly rounded; white; chorion translucent, smooth.

First instar (Fig. 8).—Length 0.76 ± 0.015; thoracic length 0.24 ± 0.005; width 0.26 ± 0.003; 9 specimens examined.

Form elongated, subcylindrical, widest across mesothorax. Body pale brownish.

Vertex subquadrate, anterior margin barely discernible, extending to or beyond level of anterior margin of eye. Frons convex and broadly rounded in lateral view; in frontal view, ovoid, about as wide as long, widest about midway from vertex to clypeal border; lateral margins convex, ventral margin concave, each lateral margin carinate (outer carina) and paralleled by a second carina (inner carina), which originates near anterior border of vertex and extends ventrally to clypeal border; 9 pits in 2 irregular rows between each inner and outer carina and 2 pits

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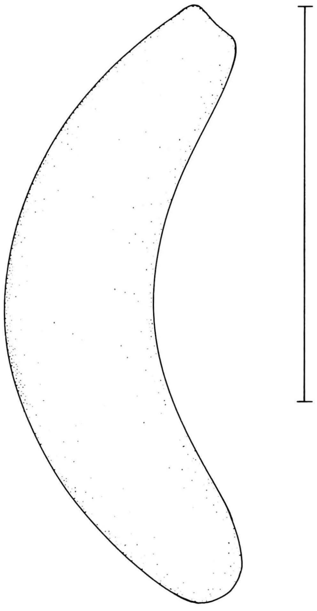

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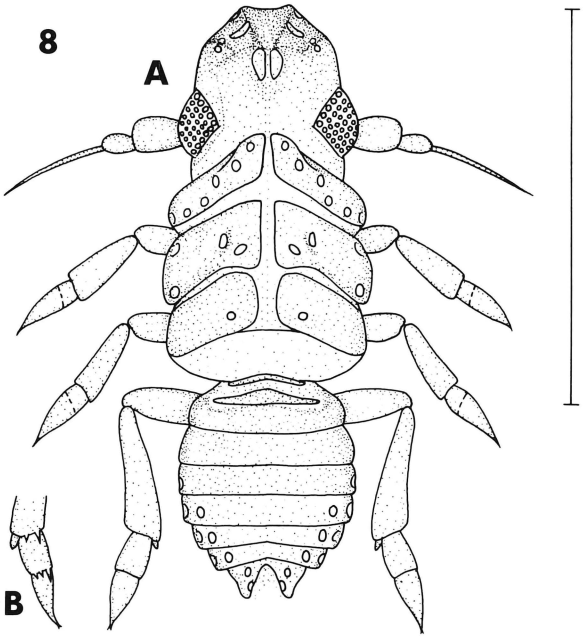

Figures 7, 8. Immature stages of *D. bellicosa*. 7. Egg. 8. 1st instar. A. Nymph, B. Ventral view of distal end of metathoracic leg. Vertical bar = 0.5 mm.

between outer carina and eye. Clypeus narrowing distally, consisting of basal postclypeus and cylindrical distal anteclypeus. Beak 3-segmented, extending to metacoxae; segment 1 almost obscured by anteclypeus, segments 2 and 3 subequal. Eyes red. Antennae 3-segmented; scape ring-like, short; pedicel subcylindrical, ca. 3× longer than scape; flagellum bulbous basally, filamentous distally, bulbous portion ca. ⅔ to ¾ length of pedicel.

Thoracic nota divided by a longitudinal middorsal line into 3 pairs of plates. Pronotum longest laterally, extending anteriorly to or beyond posterior margin of eye; each plate subrectangular, posterior margin slightly sinuate, with a short, oblique, sinuate carina extending posterolaterally from anteromedial corner; with a single row of 6 pits. Mesonotum with median length slightly longer than that of pronotum; each plate subquadrate, posterolateral margin convex, with 2 pits in median half and 2 pits near lateral margin. Metanotum with median length slightly shorter than that of mesonotum; each plate subquadrate, with 1 pit in posteromedial corner. Pro- and mesocoxae elongated, posteromedially directed; metacoxae smaller, obscured by cup-like trochanters. Metatibiae with 2 black-tipped spines apically and a very short, moveable, conical, spikelike spur; spur subequal in length to longest spine. Tarsi 2-segmented, divisions between tarsomeres very obscure; pro- and mesotarsomere 1 somewhat wedge-shaped, metatarsomere 1 with a row of 3 black-tipped spines apically; segment 2 of all legs subconical, slightly curved, with a pair of slender apical claws.

Abdomen 9-segmented, subcylindrical, widest across segments 4 and 5; segment 9 elongated vertically, surrounding anus. Segments 1 and 2 with tergites reduced to obscure plates; each segment with the following number of pits on either side of midline (lateralmost and caudal pits often not visible in dorsal view): segment 5 with 1 lateral pit on tergite, segments 6–8 each with 2 lateral pits on tergites, segment 9 with 3 caudal pits.

Second instar (Fig. 9).—Length 0.87 ± 0.003; thoracic length 0.29 ± 0.007; width 0.39 ± 0.007; 3 specimens examined.

Body slightly dorsoventrally flattened.

Vertex subpentagonal. Frons with 3 pits between each outer carina and eye. Antennae with pedicel bearing 2 ring-like sensoria on dorsal aspect near apex; flagellum with bulbous portion ca. ½ length of pedicel.

Mesonotum with each plate bearing an oblique carina originating on anterior margin ca. ⅓ distance from midline to lateral margin and extending posterolaterally to posterior margin of mesonotum; with 2 pits between midline and oblique carina and ca. 3 pits between oblique carina and lateral margin. Metanotum with each plate bearing 2 pits. Metatibiae bearing 3 black-tipped spines apically; spur 2× or more length of longest spine. Tarsi with divisions between tarsomeres distinct; metatarsomere 1 with a row of 4 black-tipped spines apically.

Third instar (Fig. 10).—Length 1.03 ± 0.027; thoracic length 0.36 ± 0.007; width 0.46 ± 0.009; 10 specimens examined.

Frons, in lateral view, convex and broadly rounded dorsally but nearly straight vertically. Antennae with pedicel bearing 4 sensoria; flagellum with bulbous portion ca. ⅓ length of pedicel.

Mesonotum with wingpads slightly lobate. Metanotum with each plate apparently bearing 1 pit. Metatibiae with 2 small black-tipped spines on lateral margin, 1 near base and 1 in basal ⅓ to ½ and a row of 5 black-tipped spines apically; spur somewhat flattened, more elongated, with 2–3 very small black-tipped teeth just before apex and 1 tooth at apex. Metatarsomere 1 with a row of 5 black-tipped spines apically.

Abdominal tergites with the following number of pits on either side of midline

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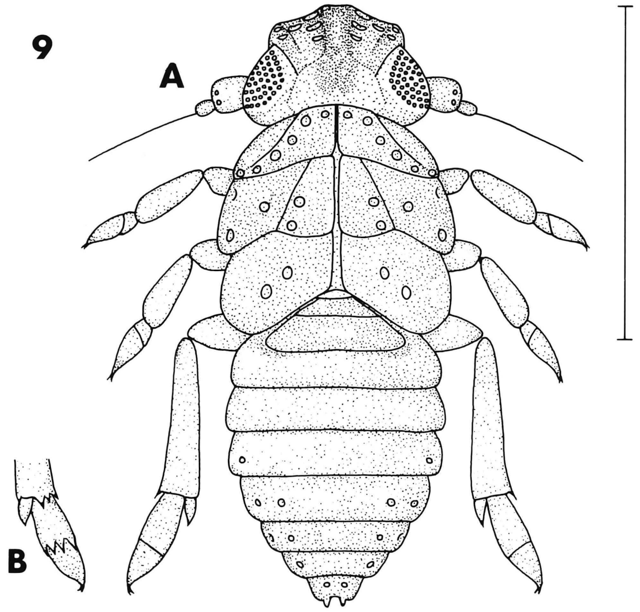

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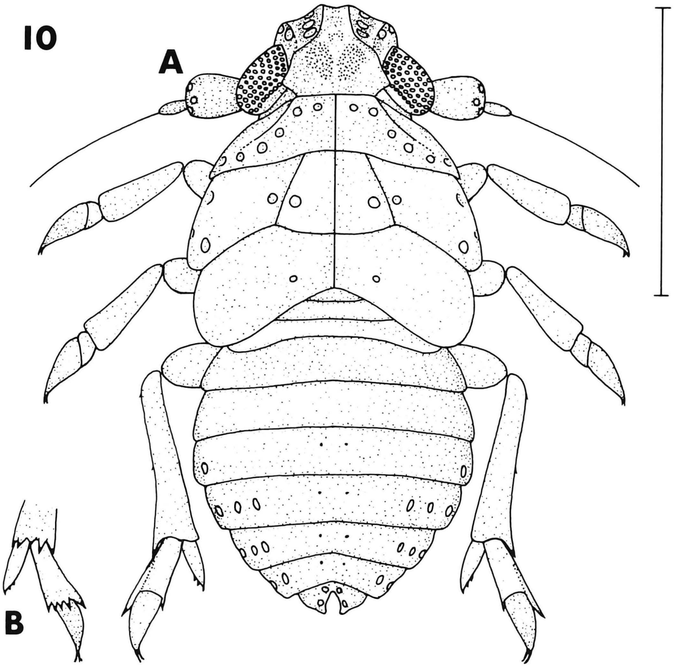
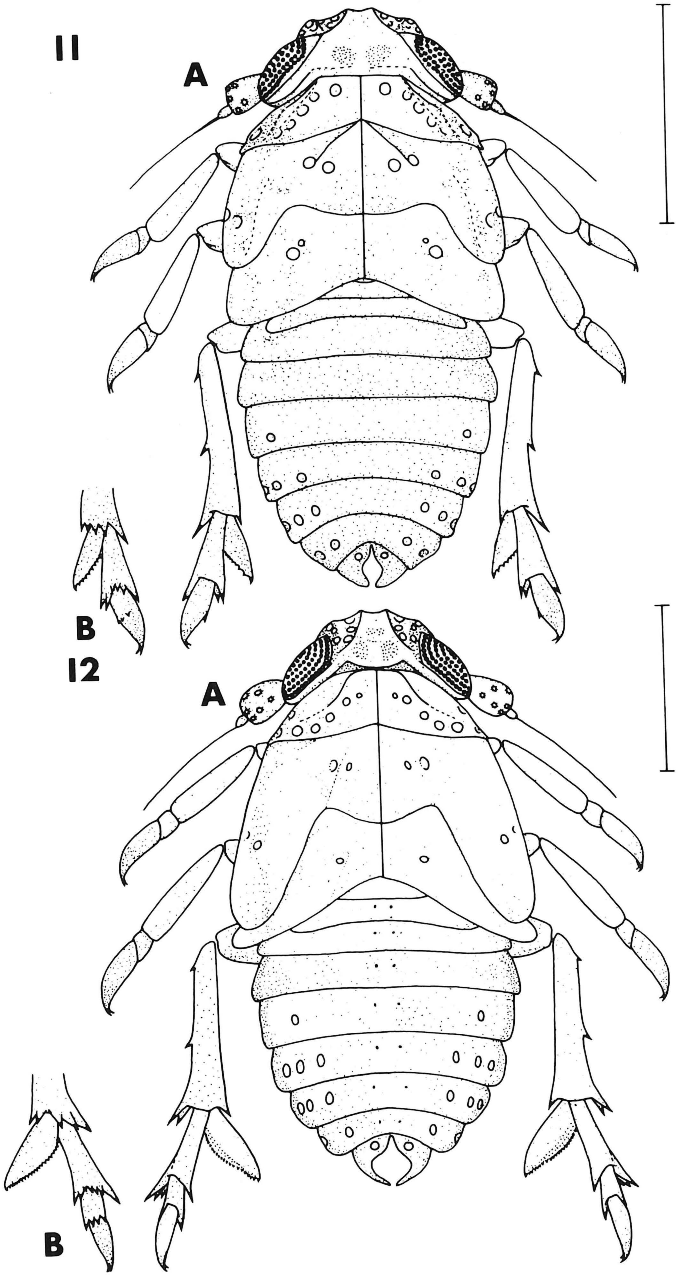


Figures 9, 10. Immature stages of *D. bellicosa.* 2nd instar. 10. 3rd instar. A. Nymph, B. Ventral view of distal end of metathoracic leg. Vertical bar = 0.5 mm.

(lateralmost and caudal pits often not visible in dorsal view): segment 5 with 1 lateral pit on tergite, segments 6–8 each with 2 lateral pits on tergite, segment 9 with 3 caudal pits.



Figures 11, 12. Immature stages of *D. bellicosa.* 11. 4th instar. 12. 5th instar. A. Nymph, B. Ventral view of distal end of metathoracic leg. Vertical bar = 0.5 mm.

Fourth instar (Fig. 11).—Length 1.62 ± 0.063; thoracic length 0.52 ± 0.013; width 0.75 ± 0.043; 6 specimens examined.

Body pale with irregular light brown markings.

Frons with 4 pits between each outer carina and eye. Antennae with pedicel bearing 6 sensoria; bulbous portion of flagellum ca. ¼ length of pedicel.

Mesonotum with wingpads distinctly lobate, covering ca. ½ of metanotal plate laterally. Metatibial spur elongate, more flattened, with a row of ca. 8 very small black-tipped teeth, spur extending almost to apex of tarsomere 1. Metatarsi with tarsomere 1 bearing a row of 6 black-tipped spines apically; tarsomere 2 with a row of 3 small black-tipped spines near middle partially subdividing tarsomere.

Fifth instar (Fig. 12).—Length 1.72 ± 0.087; thoracic length 0.57 ± 0.020; width 0.74 ± 0.025; 8 specimens examined.

Frons with length ca. 1½× width. Antennae with pedicel bearing 9 sensoria; bulbous portion of flagellum ca. ⅙ length of pedicel.

Pronotum with each plate bearing 7 pits. Mesonotum with wingpads extending to, or almost to, apex of metanotal wingpads laterally (specimens upon which this description is based are assumed to be macropters, brachypters would probably have mesonotal wingpads similar to those of 4th instars as in *Megamelus davisi* Van Duzee [see Wilson and McPherson, 1981]). Metatibial spur foliose, more elongated and flattened, with a row of ca. 15–21 very small black-tipped teeth. Metatarsi 3-segmented; tarsomere 1 with a row of 7 black-tipped spines apically; tarsomere 2 with a row of 4 black-tipped spines apically; tarsomere 3 similar to apical tarsomere of earlier instar.

ACKNOWLEDGMENTS

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Checklist of Pacific Northwest Tabanidae with New State Records and a Pictorial Key to Common Species (Diptera, Tabanidae)[1]

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Abstract.—An annotated checklist of the horse flies and deer flies of Washington, Oregon, Idaho, western Montana and southern British Columbia is presented. New state records for Washington (10 spp.) and Idaho (2 spp.) are also given. Pictorial keys are provided to assist in identifying females of 47 species in 7 genera most commonly found in the Pacific Northwest region.

Philip (1965) catalogued 65 species of horse and deer flies in 9 genera from Washington, Oregon, Idaho, and portions of Montana and British Columbia. In the nearly 20 years since Philip's compilation there have been slight adjustments in the numbers of species, including additions and deletions, some synonymy and several important range extensions. There remains a dearth of overall taxonomic works for tabanids specifically of this region. Adult horse and deer flies occurring in the Pacific Northwest (PNW) have been treated as portions of more extensive revisionary studies (Brennan, 1935; Philip, 1954, 1955; Stone, 1938), in treatments of taxonomically difficult groups (McAlpine, 1961; Teskey, 1982), or simply in descriptions of new species. Descriptions of immatures and their biologies for many PNW species can be found in Burger (1977), Lane (1975, 1979), Middlekauff and Lane (1980), and Teskey (1969). These references serve to identify the more important and recent publications that include PNW tabanids.

The present PNW checklist, preliminary to a more complete study, is the result of extensive survey/biological studies by me in Washington and recent surveys in Idaho (Nowierski and Gittins, 1976) and Oregon (Mahmoud, 1980). Additional work in Alberta (Thomas, 1973), California (Middlekauff and Lane, 1980) and Illinois (Pechuman et al., 1983) has helped to complete the picture of distribution patterns in areas adjacent to the region. As a result, a more accurate idea of the nature and composition of the regional tabanid fauna and its relationships to adjacent areas is emerging.

The following individuals allowed access to their collections and specimens in their care or shared important distribution information: P. H. Arnaud, Jr. and C. B. Philip (Calif. Acad. Sci., San Francisco); J. D. Lattin and A. A. Mahmoud (Ore. St. Univ., Corvallis); L. L. Pechuman (Cornell Univ., Ithaca); J. A. Powell and E. I. Schlinger (Univ. Calif., Berkeley); and F. C. Thompson (USDA, ARS,

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SEA, Washington, D.C.). Their assistance is appreciated. Dr. Pechuman kindly provided information on tabanid distribution for each western state and the Canadian Provinces. He along with Dr. H. J. Teskey (Canad. Nat. Coll., Ottawa) also made important comments about the particular species discussed here. Appreciation is extended to E. P. Catts for his review of the manuscript and for testing the keys.

CHECKLIST OF SPECIES

Recent specific name changes and descriptions of new species have produced several new names for western species recognized as occurring here. Some of the more important changes include the following (all new names or changes since Philip, 1965, are denoted on Table 1 with an asterisk): *Chrysops ater* Macquart now refers to western forms recognized previouly as *C. carbonarius* (Walker), a species evidently restricted to eastern North America (Pechuman and Burton, 1969; Pechuman, 1981a; and Pechuman, in Middlekauff and Lane, 1980); *Hybomitra lurida* (Fallén) supercedes *H. metabola* McDunnough (Pechuman and Stone, 1968); Pechuman (1981b) synonymized *Atylotus incisuralis* Macquart with *A. insuetus* Osten Sacken; *Tabanus similis* Macquart replaces western forms previously called *T. lineola* Fabricius and *T. lineola scutellaris* Walker as does *T. tetropsis* Bigot for *T. productus* (Middlekauff and Lane, 1980); *Hybomitra philipi* Stone was synonymized as a populational variant of *H. sonomensis* Osten Sacken and *H. enigmatica* Teskey was recognized as new and separate from related *H. sonomensis* and *H. phaenops* Osten Sacken (Teskey, 1982); *H. typha* (Whitney) was found to be restricted to eastern North America and the western forms were described as *H. pechumani* Teskey and Thompson (1979).

Subspecies and variants for three species have been recognized as valid species or evidence suggests that they should be treated as such. *Hybomitra phaenops* Osten Sacken, long recognized as a subspecies or variant of *H. sonomensis,* was elevated to specific rank on differences in immature stages and their habits (Middlekauff and Lane, 1980; Teskey, 1982). Similarly, *Apatolestes willistoni* Brennan, treated as a variant of *A. comastes* Williston, is now recognized by Middlekauff and Lane (1980) as a separate species. The latter workers and Mahmoud (1980) indicate that *A. willistoni* var. *fulvipes* Philip is the form occurring in the region (see comment below). Based on morphology and distributional data, *H. osburni* Hine is likely separate from *H. rhombica* Osten Sacken, a species which is restricted to Utah and adjacent states (Pechuman, pers. comm.).

In contrast, a number of subspecies and variants are considered here simply as populational variants. They occur occasionally as individual morphs, melanic forms, or clinal variants that apparently integrate broadly in color or pollinosity characters with typical forms in contiguous populations. They have no status and I see no need to recognize each variant. They are included here so that proper associations with their respective species can be made. Variants occurring in the PNW and references to their current status are as follows: *Apatolestes willistoni* var. *fulvipes* Philip (Middlekauff and Lane, 1980); *Pilimas californica* var. *beameri* Philip (Middlekauff and Lane, 1980); *Chrysops aestuans* var. *abaestuans* Philip (Nowierski and Gittins, 1976); *C. aestuans* var. *confusus* Krober (listed in the Nearctic Diptera catalog as a variant of *C. callidus* Osten Sacken, but Pechuman (pers. comm.) suggests that *C. callidus* probably does not occur in the west; also

Table 1. List of Tabanidae of the Pacific Northwest.

	ORE	WASH	BC	IDA	MONT
Apatolestes					
albipilosus Brennan	+				
comastes Williston	+	+	+	+	+
**willistoni* Brennan[a]	+	+	+	+	+
comastes var. *willistoni* Brennan					
var. *fulvipes* Philip					
Pilimas					
californica (Bigot)	+	+	+	+	+
var. *beameri* Philip					
Stonemyia					
tranquilla fera (Williston)	+	+	+	+	+
Silvius					
gigantulus (Loew)	+	+	+	+	+
notatus (Bigot)	+	+		+	
philipi Pechuman	+				
quadrivittatus (Say)					+
Chrysops					
**aestuans* van der Wulp	+	+	+	+	+
var. *abaestuans* Philip					
var. *pseudoconfusus* Philip					
callidus var. *confusus* Krober					
asbestos Philip	+	+	+	+	+
**ater* Macquart				+	+
carbonarius Walker					
fugax Osten Sacken					
carbonarius var. *nubiapex* Philip					
bishoppi Brennan[b]	+	+			
var. *gilvus* Philip					
coloradensis Bigot	+	+	+		
discalis Williston	+	+	+	+	+
excitans Walker	+	+	+	+	+
frigidus Osten Sacken	?	?	+	+	+
var. *xanthas* Philip					
fulvaster Osten Sacken				+	+
furcatus Walker	+	+	+	+	+
var. *chagnoni* Philip					
mitis Osten Sacken	+	+	+	+	+
nigripes Zetterstedt				?	
**noctifer* Osten Sacken	+	+	+	+	+
noctifer pertinax Williston					
proclivis Osten Sacken	+	+	+		
var. *atricornis* Bigot					
surdus Osten Sacken	+	+	+		
var. *piceus* Philip					
wileyae Philip	+				
Haematopota					
americana Osten Sacken	?	+	+	+	+
Atylotus					
**calcar* Teskey	+	+	+	+	+

Table 1. Continued.

	ORE	WASH	BC	IDA	MONT
**insuetus* (Osten Sacken)	+	+	+	+	+
incisuralis (Macquart)					
tingaureus (Philip)	+	+	+	?	+
**utahensis* (Rowe and Knowlton)	+			+	
Hybomitra					
aasa Philip	+	+	+		
affinis (Kirby)[b]		+	+	+	+
astuta (Osten Sacken)	+				
atrobasis (McDunnough)	+	+	+	+	+
californica (Marten)	+	+	+	+	+
captonis (Marten)	+	+	+	+	+
**enigmatica* Teskey	+	+	+	+	+
epistates (Osten Sacken)	+	+	+	+	+
frontalis (Walker)		+	+	+	+
fulvilateralis (Macquart)	+	+	+	+	+
hearlei (Philip)			+		
illota (Osten Sacken)		+	+	+	+
lanifera (McDunnough)	+	+	+	+	?
lasiopthalma (Macquart)[b]		+	+	+	+
liorhina (Philip)			+		
**lurida* (Fallén)		?	+	+	?
metabola McDunnough					
melanorhina (Bigot)	+	+	+	+	+
nuda (McDunnough)[b]		+	+	+	+
opaca (Coquillett)	+	?	+	+	+
**osburni* (Hine)	+	+	+	+	+
rhombica var. *osburni* Hine					
**pechumani* Teskey and Thompson[b]		+	+	+	+
typha Whitney, in part					
pediontis (McAlpine)				+	+
**phaenops* (Osten Sacken)	+			+	+
sonomensis var. *phaenops* Osten Sacken					
procyon (Osten Sacken)	+	+	+	+	+
rupestris (McDunnough)	+	+	+	+	+
sequax (Williston)	+	+	+	+	+
**sonomensis* (Osten Sacken)	+	+	+		
**philipi* Stone					
tetrica (Marten)	+	+	+	+	+
var. *hirtula* Bigot					
var. *rubrilata* Philip					
trepida (McDunnough)[b]		+	+	+	?
zonalis (Kirby)[a]		?	+	+	+
zygota (Philip)[b]	+	+	+		
Tabanus					
aegrotus Osten Sacken	+	+	+	+	+
fratellus Williston	+	+	+	+	+
kesseli Philip	+	+	+	+	+
laticeps Hine	+	+	+		
marginalis Fabricius[b]		+	+	+	?
monoensis Hine[b]	+	+		+	
punctifer Osten Sacken	+	+	+	+	?
reinwardtii Wiedemann					+

Table 1. Continued.

	ORE	WASH	BC	IDA	MONT
**similis* Macquart	+	+	+	+	+
lineola Fabricius					
lineola scutellaris Walker					
stonei Philip	+	+	+	+	+
var. *jellisoni* Philip					
**tetropsis* Bigot[b]	+	+	?	+	+
productus Hine					

[a] New Idaho state record.

[b] New Washington state record.

see Nowierski and Gittins, 1976); *C. bishoppi* var. *gilvus* Philip (Middlekauff and Lane, 1980); *C. frigidus* var. *xanthus* Philip (Nowierski and Gittins, 1976); *C. furcatus* var. *chagnoni* Philip (Thomas, 1973); *C. proclivis* var. *imfurcatus* Philip and var. *atricornis* Bigot (Middlekauff and Lane, 1980); *C. surdus* var. *piceus* Philip (Middlekauff and Lane, 1980); *Hybomitra tetrica* var. *hirtula* (Bigot) (Middlekauff and Lane, 1980). The subspecies *Chrysops noctifer pertinax* Williston is treated likewise (Middlekauff and Lane, 1980).

Total diversity of genera and species seems to vary little among the PNW states and western Canadian province of British Columbia. All areas share the same nine genera (if one assumes that *Haematopota* occurs in Oregon, although it is not yet recorded from there). The overall diversity of species is likewise very similar with the greatest number occurring in southern British Columbia (56) and the least in western Montana (49). Tallies of species for other PNW states are Washington (54), Idaho (54) and Oregon (52). British Columbia shares similar coastal habitats and associated fauna with Washington and Oregon, but it also receives more boreal and montane faunal influences from the north and northeast. These northern relationships increase the diversity for British Columbia as several species do not extend farther south into the states. The low number of species in Oregon is surprising as one would expect its southern portion to be influenced by California to the south. I suspect that Oregon, Montana and Idaho may show greater diversity in the final analysis, but their fauna has been insufficiently collected.

The limited distribution of some species may reflect a lack of collecting or actually represent species that are geographically limited. Four *Chrysops* species (*C. ater, C. frigidus* Osten Sacken, *C. fulvaster* Osten Sacken, and *C. nigripes* (Zetterstedt)) are known from the eastern portions of Montana and Idaho, but they have not been collected or have questionable records in Washington and Oregon. *Tabanus reinwartii* Wiedemann likewise is a midwestern species that has invaded the eastern foothills of the Rocky Mountains in Montana but no farther west. While many species have wide distributions throughout the PNW region, others with similar patterns have not been recorded in certain areas. For example, it is difficult to explain the following absences: *Atylotus tingaureus* (Philip) from Idaho; *Tabanus marginalis* Fabricius, *T. punctifer* Osten Sacken, *Hybomitra lanifera* (McDunnough) and *H. lurida* from Montana; *H. pechumani, H. lurida, H. opaca* (Coquillett), and *H. zonalis* (Kirby) from Washington; *Tabanus tetropsis*

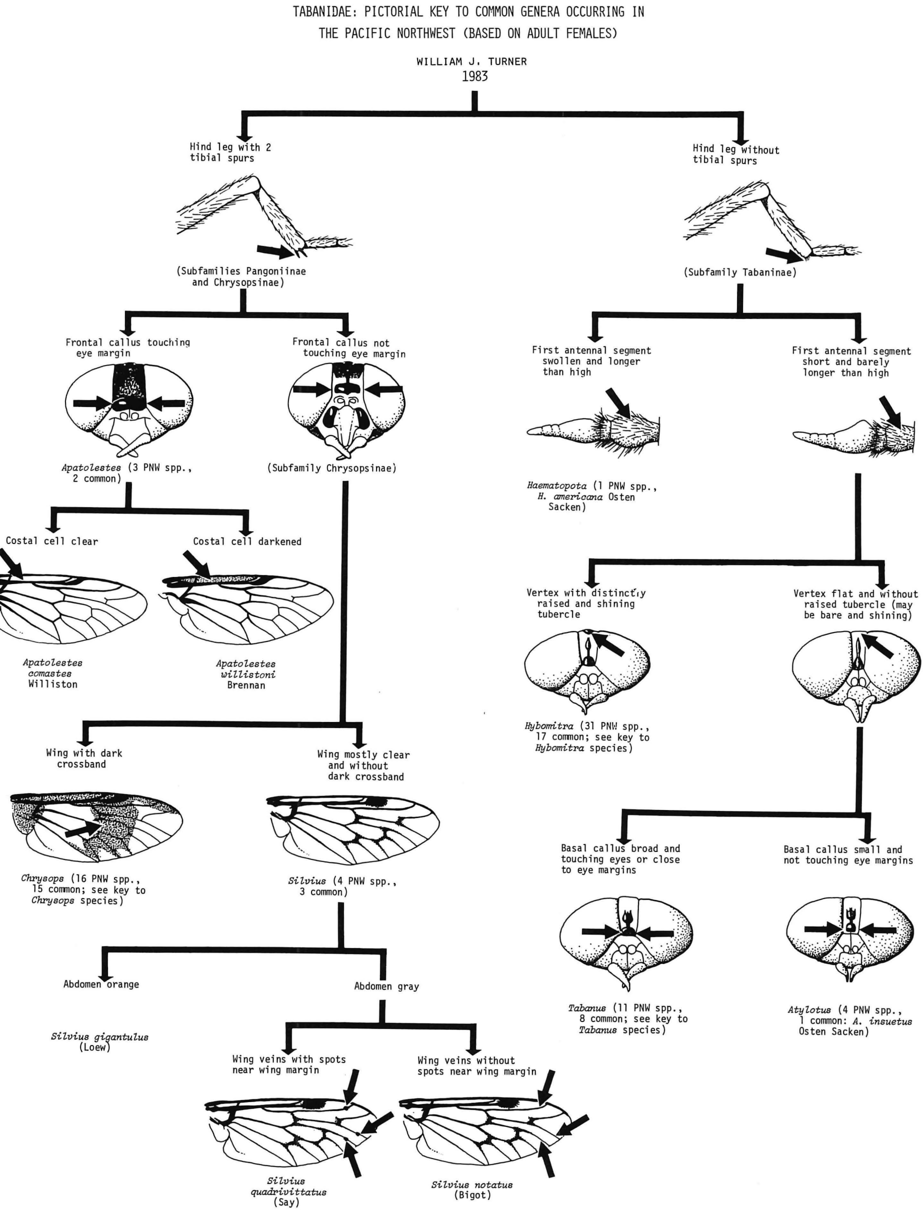

Figure 1. Pictorial key to common genera occurring in the Pacific Northwest (based on adult females).

from British Columbia; and *Haematopota americana* Osten Sacken from Oregon. Finally, it is equally difficult to explain the very restricted and perhaps relict population of *H. astuta* (Osten Sacken). Reported from one Oregon locality (Mahmoud, 1981), it has not been collected in any other PNW area.

Several primarily northern and eastern species have been recorded from northern Idaho, northern Washington and British Columbia. They are usually en-

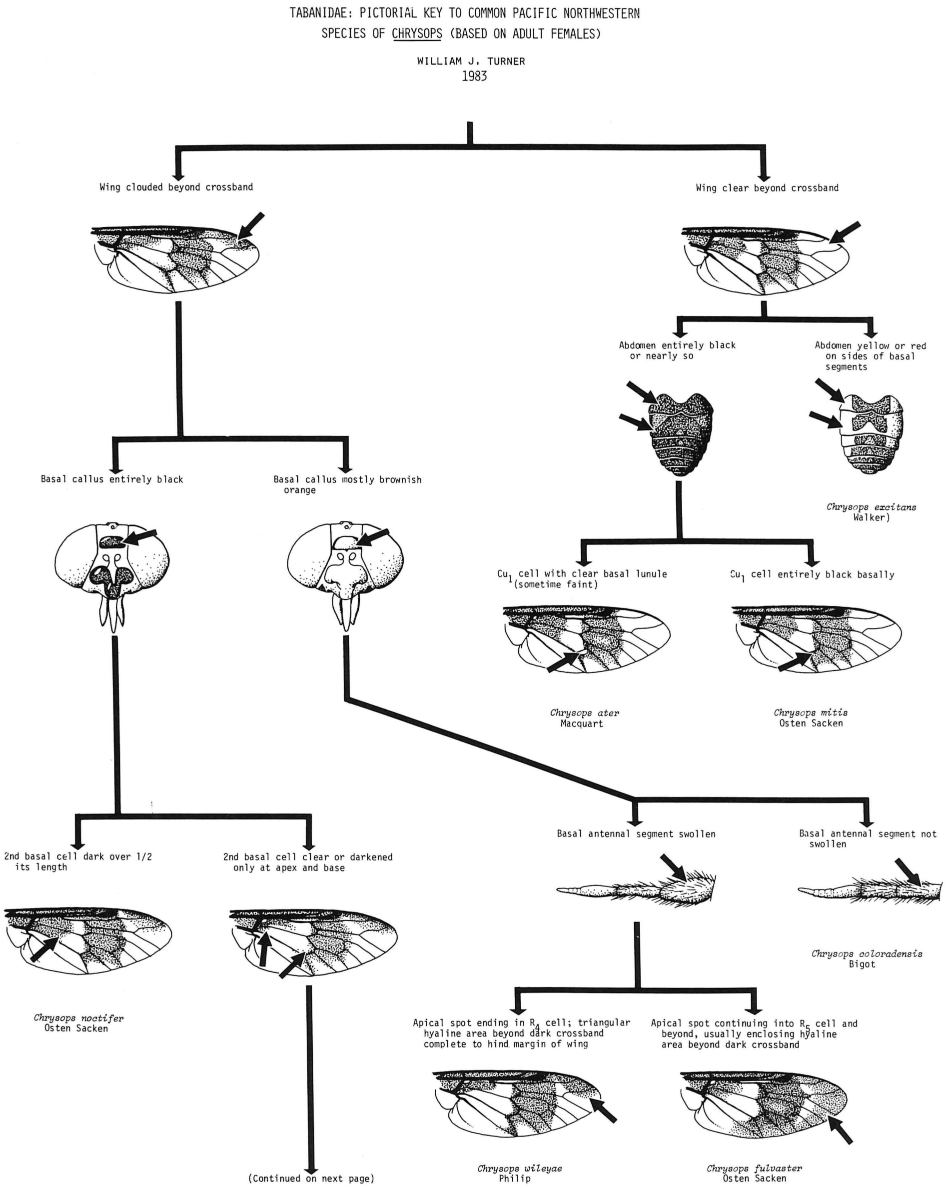

Figure 2. Pictorial key to common Pacific Northwest species of *Chrysops* (based on adult females).

countered at higher latitudes in the west. One-half (5 of 10) of the species reported here as new state records for Washington show this northeastern influence in the region. These include: *Hybomitra affinis* (Kirby), *H. lasiopthalma* (Macquart), *H. nuda* (McDunnough), *H. trepida* (McDunnough) and *Tabanus marginalis.* Other new Washington records for *Chrysops bishoppi* and *Tabanus monoensis* Hine represent species that are widely distributed but only recently collected in the state. The remaining two species new to Washington (*Hybomitra zygota* (Philip) and *Tabanus tetropsis*) have been collected in adjacent areas and represent antic-

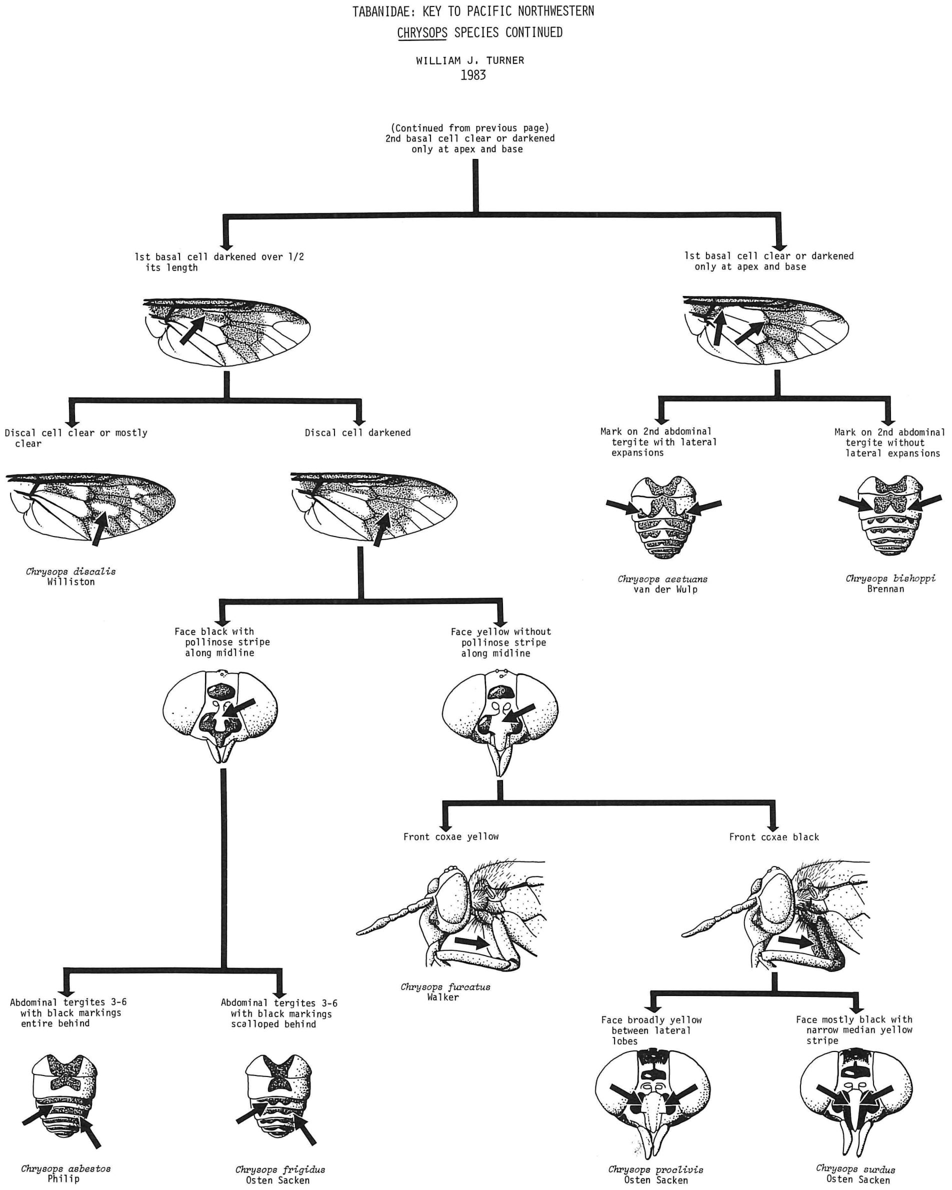

Figure 3. Key to Pacific Northwest *Chrysops* species continued.

ipated range extensions into Washington. The two new Idaho records are for *Apatolestes willistoni* Brennan and *Hybomitra zonalis.* The last is another northern species that eventually should be collected in northeastern Washington.

PICTORIAL KEYS

Among important blood-sucking Diptera, the horse and deer flies represent one group that is easily recognized by the non-specialist. Unfortunately, the body of literature available for identifying tabanids is written primarily for the taxonomic

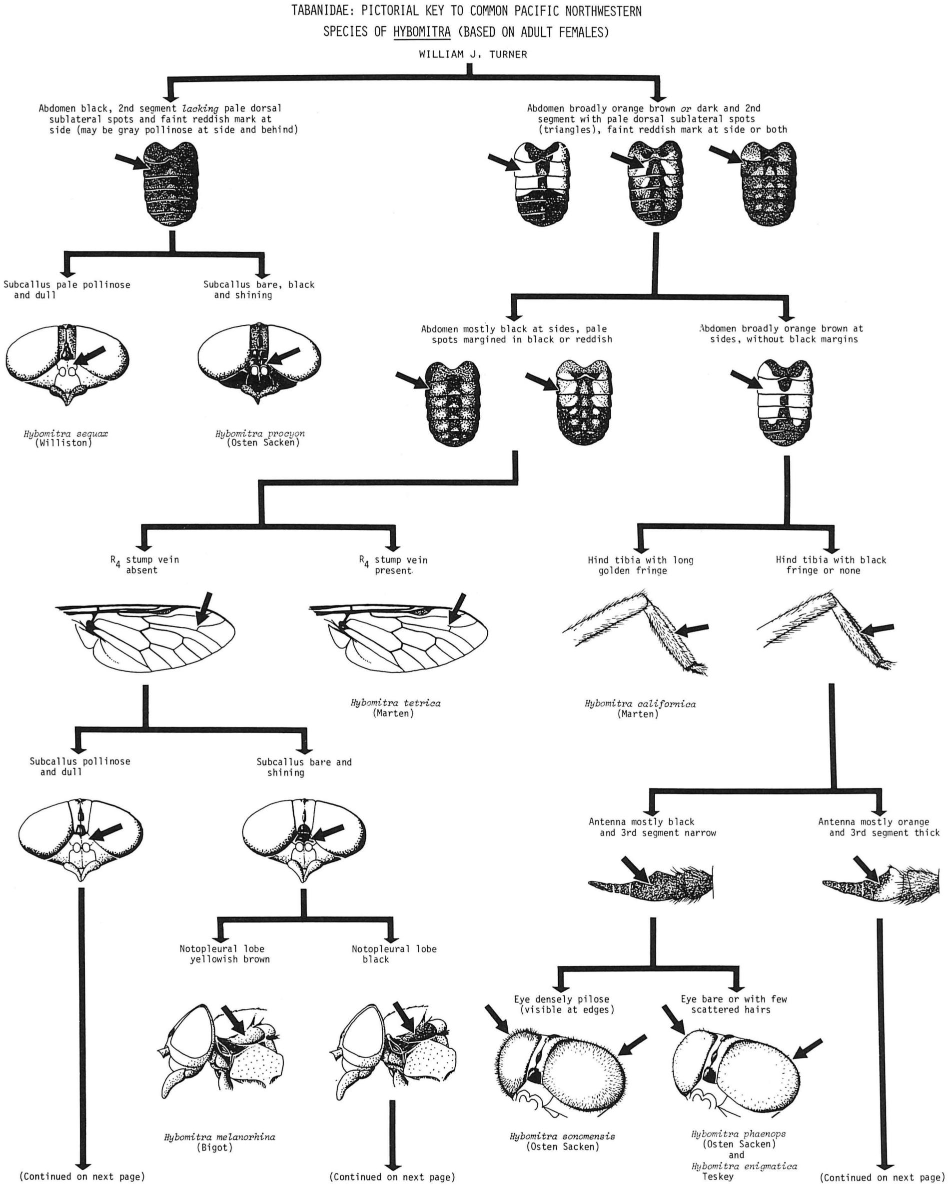

Figure 4. Pictorial key to common Pacific Northwest species of *Hybomitra* (based on adult females).

specialist. The keys provided here represent one attempt to develop taxonomic works for more general use on this important group of biting flies. In format the keys are modeled after the CDC series of keys to arthropods and other animals of medical importance (U.S. Dept. Health, Educ., Welfare, 1967). These keys are easier to use than more traditional ones which are often limited to word descriptions and a plethora of technical terms. In all cases where precise identifications are necessary, determinations should be considered tentative until checked by a specialist.

The included keys have been limited to include the more common species and

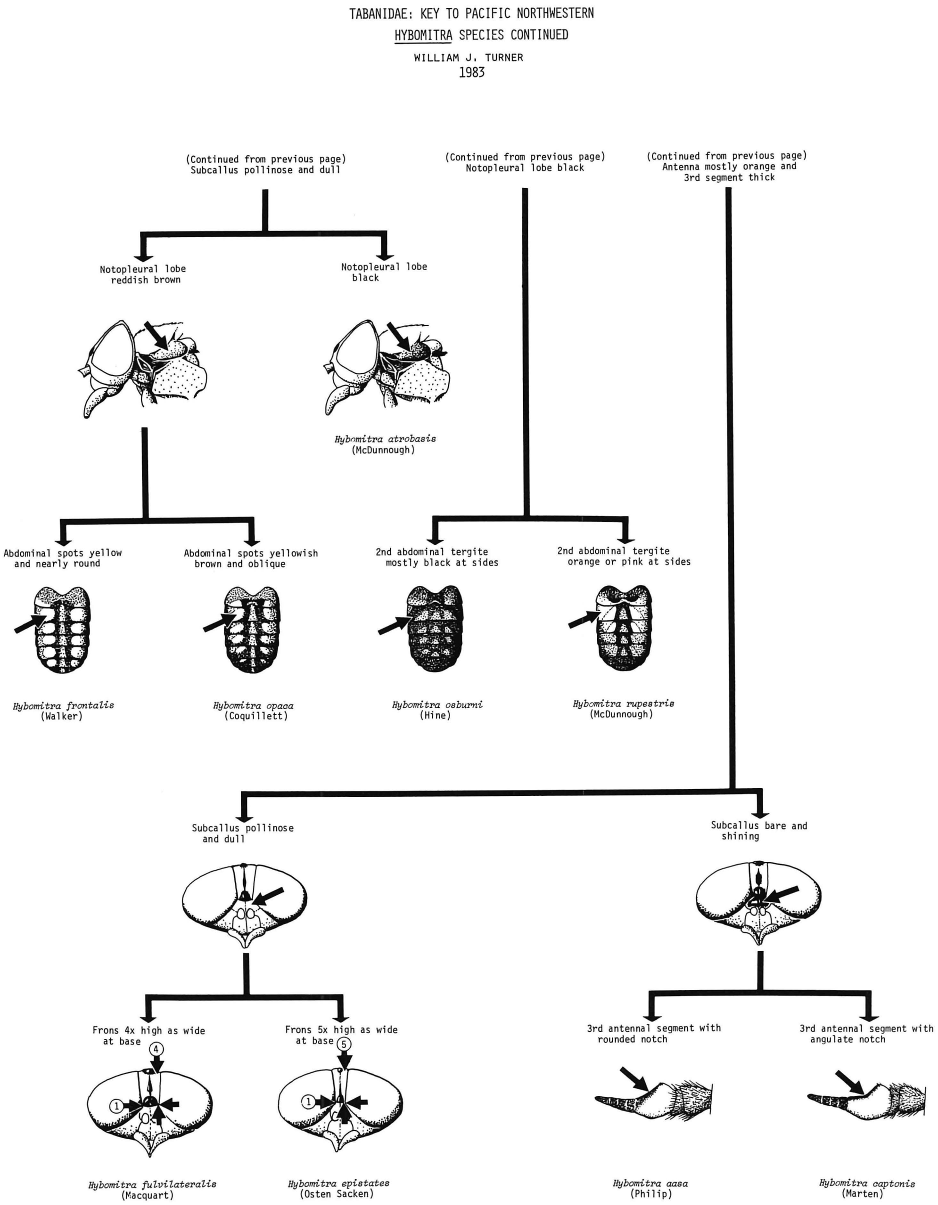

Figure 5. Pictorial key to common Pacific Northwest *Hybomitra* species continued.

genera of tabanids. Whole groups were excluded because they are considered uncommon (i.e., those that are rarely encountered or poorly collected; for example, species of *Stonemyia* and *Pilimas*). Species were judged to be "common" after reviewing published and unpublished distribution records, past requests for determinations or biological information, and lists of data collected from museum specimens or associated with field survey samples and studies from the region. In some keys, however, several less common biting species have been included because either the groups were small (e.g., *Silvius*) or the similar-appearing rarer species might be confused with strictly common ones (e.g., some species of *Chry-*

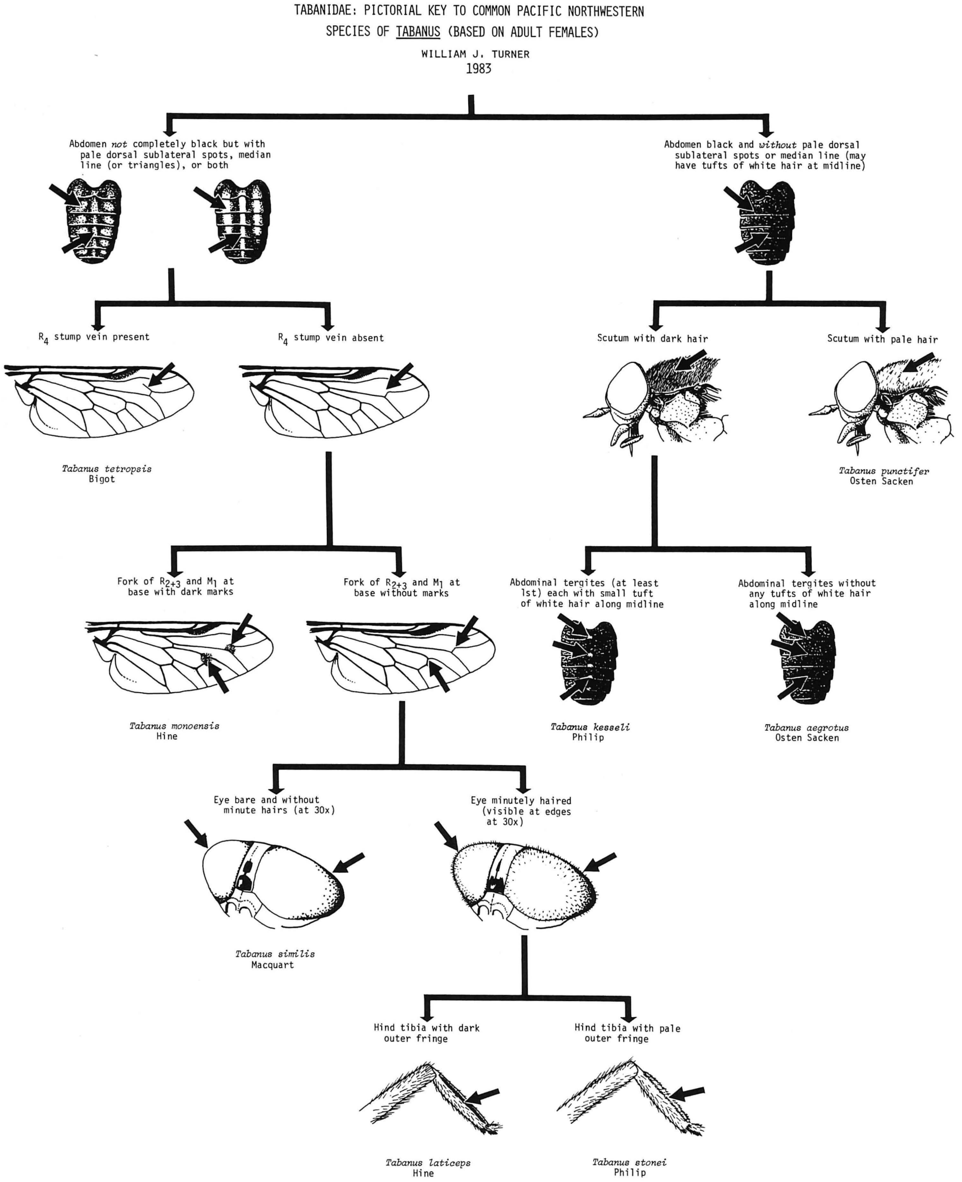

Figure 6. Pictorial key to common Pacific Northwest species of *Tabanus* (based on adult females).

sops; also *Hybomitra*). The keys also are restricted to females as most records and identification requests involve females that are regularly attracted to humans, animals or baited traps. Males of all species, in contrast, do not seek animal hosts or suck blood and are therefore rarely encountered.

In one couplet of the key to the species of *Hybomitra,* I have not separated two species, *H. phaenops* (Osten Sacken) and *H. enigmatica* Teskey. Both are common, very similar and not readily identified without rehydrating the heads in order to restore the prominent eye bands visible in living material (see Price and Goodwin, 1979 for technical details of the method). In *H. phaenops* the dark horizontal bands are wider and extend completely to the lateral eye margin while the upper and lower margins are darkened. In contrast, the bands in *H. enigmatica* are thinner and do not reach the eye margin while the darker margins above and below are absent. Specimens keyed to *H. phaenops/enigmatica* should be referred to a specialist for positive identification.

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A New Genus and Species of Horse Fly (Diptera: Tabanidae) from Bolivia[1]

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The following description of a new genus and species presents another example of the continuing discovery of neotropical horse fly diversity. It indicates to me the high potential of finding many more unstudied higher taxa in this part of the world. It is with reluctance that I would describe a new species from a single specimen, let alone a new genus, but in this case it is quite clear that the species is distinct and requires generic status.

Roquezia **Wilkerson, NEW GENUS**
(Tabanidae: Tabaninae: Diachlorini)

Diagnosis.—Frons relatively wide, convergent below. Basal callus square and protuberant, not touching sides of frons. Eyes bare. A slightly raised tubercle at vertex bears 3 small ocelli. Antennal basal plate slender, dorsally bluntly rounded, style 4 annulate. Palpus short, greatly inflated but sharply pointed. Scutum pale gray and dark brown striped. Wings glass-clear, venation normal, vein R_{4+5} with a short appendix. Basicosta without macrotricheae (bare). Abdomen above blackish brown with a series of large sublateral pale gray spots on tergites 3–6. Tergites 1 and 2 largely gray pollinose.

The overall impression is of a muscoid fly.

Type of genus.—*Roquezia signifera* Wilkerson, new species.

Etymology.—Named for Roberto Vasquez C., Bolivian botanist and generous host during my visits to Bolivia.

Roquezia signifera **Wilkerson, NEW SPECIES**
(Figs. 1–4)

Diagnosis.—A small muscoid appearing dark brown and pale gray species with shiny square basal callus, small but distinct ocellar tubercle and short, swollen, pointed palpi. Scutum pale gray striped, wing glass-clear and legs black. Abdomen above with large pale gray sublateral spots except on tergite 2 which, except for a median dark brown triangle is entirely pale gray.

Female.—Length: body 8 mm; of wing 9 mm. Head structures in Figures 1–3. Frontal index 5.0. Frons narrowed below, width at vertex/width at base = 1.7. Frons, subcallus, gena, frontoclypeus and postocciput pale gray pollinose with a faint yellowish tint. Vertex darkened, area around the tubercle shiny black; dorsal to this shiny area integument dark and sparsely dark brown pollinose. Frontal

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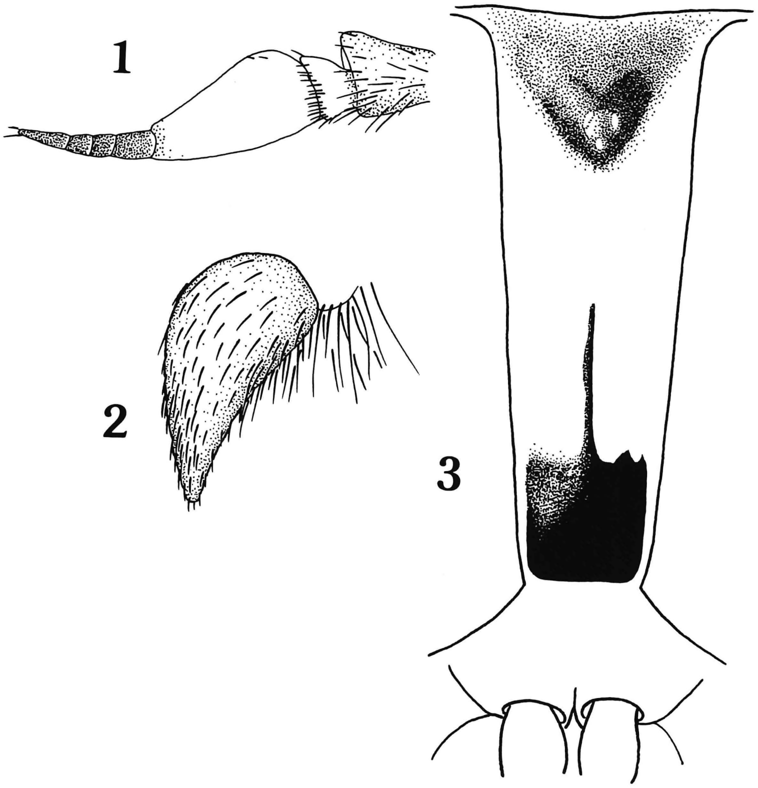
[1] Florida Agricultural Experiment Station Journal Series No. 5805.



Figures 1–3. Head structures of female *Roquezia signifera* Wilkerson, new species. 1, Antenna. 2, Palp. 3, Frons.

hairs mostly black, short and sparse; those at vertex longer and more numerous; those on lower ½ of frons quite sparse and pale. Ocellar tubercle small and slightly raised bearing 3 small yellowish brown ocelli. Ocelli seem to be covered by pollinosity and are not protuberant. Eyes bare, color and pattern not recorded. Basal callus a protuberant shiny black square with a slender upward extension. Subcallus with small sublateral bare spots, apparently the result of rubbing. Numerous short pale yellow hairs present on gena, less dense laterally on frontoclypeus. Beard of numerous short pale yellow hairs. Antenna pale reddish brown, the annuli darker brown; antennal hairs black. Second palpal segment short, much swollen basally but apically acutely pointed; integument pale yellowish brown, sparsely pale gray pollinose and black haired except for a few pale hairs beneath. Proboscis short, wholly fleshy and black. In this specimen it is retracted but stylets are short and reach only to tip of palpus. Labella about as long as palpus.

Scutum and scutellum as in Figure 4. Pale areas of scutum pale gray pollinose, the dark areas with a dark brown integument covered with sparse dark brown pollinosity. Scutellum blackish brown. Scutal hairs short, sparse and black; hairs of scutellum also sparse and black but longer. Pleura, and mid and hind coxae, blackish brown overlain with sparse pale gray pollinosity. Pleural hairs short, sparse and black; those below wing base longer. A small clump of yellow hairs

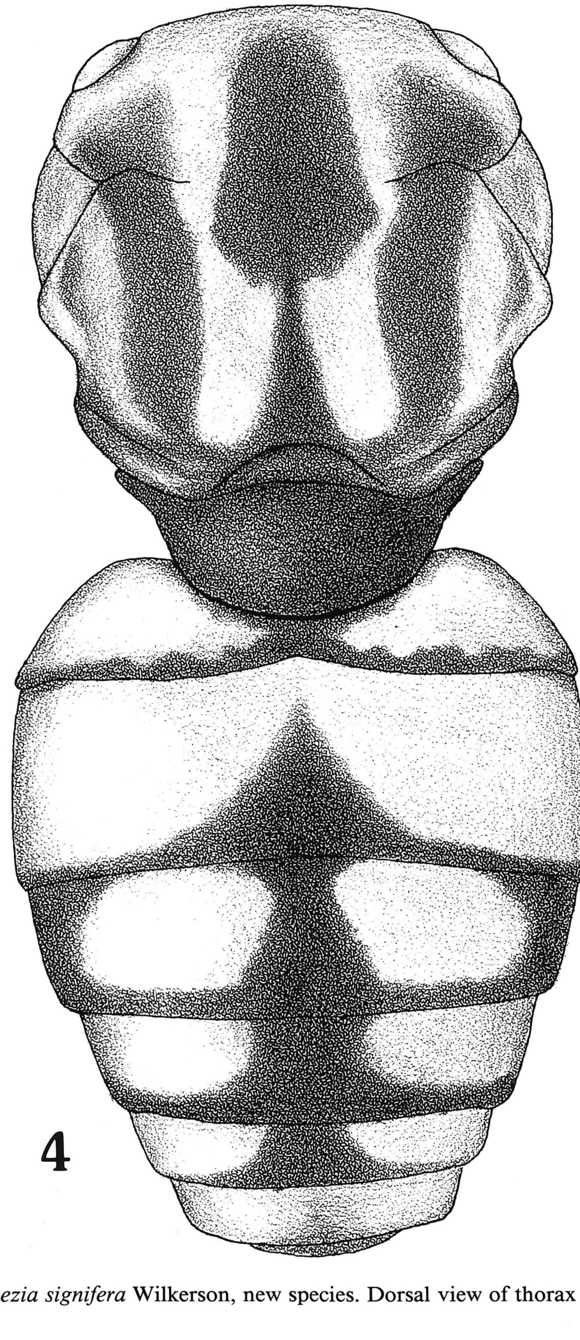


Figure 4. *Roquezia signifera* Wilkerson, new species. Dorsal view of thorax and abdomen.

present in front of wing base. Fore coxae mostly pale yellowish gray pollinose and pale yellow haired. Legs black and black haired. Wing including costal cell glass-clear, venation normal; R_{4+5} (fork of 3rd vein) with a short appendix. Basicosta bare. Squamae pale, with a fringe of white hairs. Halteres brown but tip of knob yellow.

Abdominal dorsum as in Figure 4, dark areas blackish brown, pale areas pale silvery gray pollinose. Dorsum wholly sparsely short black haired. Venter dark blackish brown in ground color, pale bluish gray pollinose and wholly short black haired.

Male.—Not known.

Type.—Holotype female, Santa Cruz Department, Bolivia, 10 km E Warnes, 22-VIII-1983, R. Wilkerson coll. To be deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

Etymology.—Signifera is from the Latin meaning bearing marks, figures or signs.

Discussion.—Tribe Diachlorini (Tabaninae, Tabanidae) remains a confusing group of genera and subgenera whose relationships are not yet understood (Fairchild, 1969). The tribe comprises more than half of the neotropical species of Tabanidae and is united, perhaps artificially, by the following: "Basicosta smoothly pollinose, without setae. If setae are present, sparse or numerous, and there are vestiges of ocelli, a strong tubercle at vertex, labella partly sclerotized, a long tooth on third antennal segment, wings strongly patterned or other striking specializations" (Fairchild, 1969).

Roquezia belongs in this assemblage by virtue of its bare basicosta. Several species or species groups in Diachlorini superficially resemble *Roquezia* because of their muscoid fly appearance (mimicry?). *Stypommisa marucii* (Fairchild) and most *Philipotabanus* (*Mimotabanus*) Fairchild differ by having a clavate callus and elongated palpi. In addition they have bluish pruinosity on the first 2 abdominal segments and *P. Mimotabanus* has a patterned wing. *Myiotabanus* Lutz differs by having a longer proboscis, partly sclerotized labella, partially bare subcallus, a large ovoid basal callus, no vestiges of ocelli and short stubby antennae. *Eutabanus pictus* Kröber differs by having protuberant and conical notopleural lobes, inflated fore tibiae, flattened hind tibiae, broad divergent frons, large drop-shaped callus and a small discal wing band.

Roquezia seems to be most closely related structurally to *Stenotabanus* Lutz, many species of which have glass-clear wings, short fleshy labella, short, basally swollen palpi, similar antennae, vestiges of ocelli, frons convergent below, and protuberant square basal callus, sometimes with a thin dorsal extension.

Roquezia, however, differs in 2 significant ways from any *Stenotabanus* known to me. First, the frons differs by having a basal callus that does not touch the sides of the frons and there is no median darkened area on the frons evident in most *St.* (*Stenotabanus*). Secondly, no *Stenotabanus* seen has a thoracic and/or abdominal pattern similar to *Roquezia.*

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